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## DOCTOR OF PHILOSOPHY

### Interceptive orthodontics

the evidence, current general dental practice, and way forwards in the UK

Borrie, Felicity Ruth Peters

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Felicity Ruth Peters Borrie

2013

University of Dundee

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# Interceptive Orthodontics; The evidence, current general dental practice, and way forwards in the UK

A Thesis submitted to the University of Dundee for the degree of

Doctor of Philosophy

to the Faculty of Medicine, Dentistry and Nursing by

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## **DECLARATION**

I declare that the work presented in this thesis is all my own work, has not been previously accepted for a higher degree and I have consulted all references cited.

Felicity Borrie

I confirm that the conditions of the relevant Ordinance and Regulations have been fulfilled.

Professor David Bearn (Supervisor)



## ABSTRACT

### Aim

This thesis has several aims;

- to explore the available evidence surrounding interceptive orthodontics (IO),
- to explore current general dental practice with regard to the provision of interceptive orthodontic care, and
- to consider the way forward in the UK for providing simple interceptive orthodontic care for children in primary care.

### Methods

Systematic reviews were conducted in areas where there had previously been no high quality reviews; interventions for the cessation of non-nutritive sucking habits (NNSH) in children, and correction of anterior crossbites in children. Semi-structured interviews were performed, transcribed, and thematic analysis performed, helping to develop a questionnaire. Following development, the questionnaire was posted to 400 General Dental Practitioners (GDPs) across Scotland. The results were analysed, and potential barriers to providing care were identified. A cost analysis was performed, using some of the data from the questionnaire to calculate the current cost to the NHS of managing children with persistent digit sucking habits. A sensitivity analysis was constructed to predict if a saving could be made to the NHS, if there was a change in clinical practice in primary care. Finally, a protocol for an interventional study was developed using the results from some of this work, to increase the provision of IO in primary care.

### Results

The systematic review of interventions for NNSH identified 183 initial papers, which after checking for relevance and quality, were reduced to a final six RCTs which

were included in the final review. The results suggested that a fixed habit breaker was the most effective intervention for digit suckers. The systematic review of correction of anterior crossbites in children identified 499 papers, which after checking for relevance and quality, were reduced to a final 46 studies which were included in the final review. The results suggested that anterior crossbites were best managed with a fixed “2 x 4” appliance. The interviews suggested confidence, and previous experience may play a role in determining whether a GDP will provide IO. The questionnaire highlighted that confidence, knowledge, and age could all be barriers to providing care, and these were the focus for the design of the intervention study. The cost analysis demonstrated that a potential saving of approximately £20,000 to NHS Tayside could be made by changing current practice from provision of a URA to a fixed habit breaker. If this change was implemented across Scotland this saving could increase to over £1,000,000. Larger savings could be made if less monitoring of the habit and more provision of fixed habit breakers was implemented (over £60,000 in NHS Tayside).

## **Conclusions**

The systematic reviews highlighted the need for high quality studies in their subject areas. The cost analysis demonstrates the range in savings that could be made to the NHS depending on the changes made to current GDP practice. The interviews and questionnaire demonstrated there is scope to improve the provision of IO in primary care. The biggest barrier to providing IO appears to be confidence, specific to designing treatment plans, and how effectively the plan can be carried out for the patient. It is intended that the proposed investigation, outlined at the end of this thesis, to increase GDPs provision of IO, will be conducted. If the intervention proves successful, it could be rolled out across the UK, changing current clinical practice.

## **Chapter 1**

### **Introduction, Aims and Objectives**

## 1.1 Background

Interceptive orthodontics is a term that includes a range of interventions in the mixed dentition which aim to prevent or reduce the degree of malocclusion in the permanent dentition.

It was not until I started working in Dundee Dental Hospital, as a Senior House Officer in both the Unit of Orthodontics, and Paediatric Dentistry that I became aware of the number of missed opportunities to intercept in patients with a developing dentition. I perceived there to be a disparity between what was being taught to dental undergraduates on this subject and what was being provided by General Dental Practitioners (GDPs). This led me to the idea that many children may benefit from an interceptive procedure but often it is not provided.

Whether this lack of provision was due to lack of knowledge, confidence, skills, evidence for success, the remuneration system, or a combination of these factors, was not clear but it seemed that many GDPs did not implement interceptive orthodontics, contradicting their holistic undergraduate teaching and it is this I wished to investigate.

As preventive and interceptive orthodontics are terms often used synonymously, this had led to confusion between the conceptual and operational definitions of both terms (Ackerman, 1980, Tulloch, 2004). Conceptually, it is felt that these terms relate to the possibility of treating young patients in ways which will obviate the need for later comprehensive treatment. Operationally, the terms concern procedures or techniques for the treatment of patients. These authors have defined interceptive orthodontics as the elimination of existing interferences with the key factors involved in the development of the dentition, and preventive orthodontics as prevention of potential interferences with occlusal development.

Popovich and Thomson (1975) defined interceptive orthodontics as procedures that eliminate or reduce the severity of a developing malocclusion, and preventive orthodontics as any action taken to preserve the integrity of a normal occlusion.

Graber (1972) also defined the two concepts, with preventive orthodontics described thus “the primary charge of the dentist who would render preventive orthodontic service is that he strives to maintain a normal occlusion for that particular age,” and interceptive orthodontics as “required for developing basal dysplasias, cleft palate problems, anterior diastemas, habit problems, arch length deficiency problems, and

so forth.” He further added that preventive orthodontics would include space maintenance, oral habit check-ups and caries control, and interceptive orthodontics would include space regaining appliances and serial extractions.

Although there have been attempts to separate preventive and interceptive orthodontics, much of the literature fails to distinguish between preventive and interceptive treatment. For the purpose of this thesis, the term interceptive orthodontics will be used to include both interceptive and preventive procedures, and therefore includes intervening in a wide range of situations including:

- crossbites, anterior and posterior;
- eruption problems / impaction (including incisors and canines);
- poor quality first permanent molars;
- infra occluded deciduous molar teeth;
- non-nutritive sucking habits (digit and pacifier sucking) leading to anterior open bites, posterior cross bites and increased overjets;
- centreline shifts related to unilateral loss of deciduous teeth; and
- increased overjet and associated risk of trauma.

Studies have been conducted to determine the prevalence of malocclusion in children requiring treatment, and reports vary from 26 to 39% (Burden and Holmes, 1994, Hiles, 1985, Tausche et al., 2004, Väkiparta et al., 2005) depending on the age range investigated. The GDP plays a very important role in the identification and diagnosis of orthodontic problems presenting early, and assessing the potential for their development. It is believed that if intercepted and correctly managed during the mixed dentition, many malocclusions can be eliminated, saving the patient from complex orthodontic treatment at a later stage (Al Nimri and Richardson, 2000).

Patients are unknowingly dependent on their GDP's orthodontic diagnostic skills and appropriate management, whether that involves a referral to a specialist orthodontist, or interceptive treatment within the practice.

In Finnish health centers, the general dentists work together in the same organization as the orthodontists, facilitating joint action, with the screening of patients for orthodontic treatment undertaken by the generalist, often as early as the age of seven years. The orthodontist diagnoses the malocclusion and formulates a treatment plan for the GDP to undertake (Pietilä et al., 1997). In the UK, although orthodontic screening is part of routine care by the GDP, the diagnosis, formulation and

execution of the treatment plan is often performed by the orthodontist, even for simple interceptive procedures. This raises the question whether this is the best use of limited resources, both clinically and economically.

Interceptive treatment potentially reduces the need for further, more complex orthodontic treatment (Jolley et al., 2010), and, therefore, may be of particular benefit to patients and clinicians in areas where there is limited access to specialist orthodontic services. In addition, there is a potential cost benefit to providing successful treatment early, with simple appliance therapy in general practice when compared to fixed appliance therapy, which is usually provided by a specialist orthodontist.

If fixed appliances are avoided by judicious interceptive treatment then there is, in addition, a decrease in the potential for iatrogenic damage to teeth, in the form of white spot lesions and root resorption, both recognised common risks of fixed appliance treatment. It has been reported that there is a significant correlation between length of fixed appliance treatment and amount of apical root resorption (Apajalahti and Peltola, 2007) and the prevalence of white spot lesions can range from 15 to 85% of patients after fixed orthodontic treatment (Gorelick et al., 1982, Mitchell, 1992).

One very important aspect of successful provision of interceptive treatment is patient co-operation. The majority of interceptive orthodontics involves the use of removable appliances which are highly dependent on patient compliance. Even before the appliance can be fitted a dental impression usually has to be taken, and this can be traumatic for a young patient. Other types of interceptive treatment can involve extraction of deciduous teeth, which can be a very distressing procedure for a young child. Therefore, it can be seen that providing treatment may not be straightforward in this age group of nine to ten years of age.

Recent findings show that a very high proportion of children are registered with an NHS dentist in Scotland; 99% of those six to twelve years of age (ISD, 2012).

However, these figures do not reveal how often children are attending the dentist, and for many it may represent a one off emergency visit or infrequent appointments, as patients are now not automatically de-registered after a period of non-attendance. Perhaps it is these irregularly attending children that need to be even more carefully examined, with regard to the presence of an occlusal anomaly and the potential for providing interceptive treatment, as they will be less likely to attend later for a more

complex course of treatment. For example, although it would not be sensible in a high caries risk mouth, where deciduous molar extractions are required, to consider fitting a space maintaining appliance, it would be worth checking for normal eruption sequence of the permanent dentition and palpation of maxillary permanent canines, and if necessary consider extracting a deciduous canine. This may prevent ectopic positioning of a maxillary permanent canine, with the subsequent need for surgical exposure and orthodontic traction if the tooth is to be aligned.

Interceptive orthodontics has featured often in the orthodontic literature over the past few years, with the emphasis being to reduce the later need for publicly funded complex orthodontic treatment (Väkiparta et al., 2005, Bresnahan et al., 2010, Jolley et al., 2010). It is accepted that interceptive orthodontics will not produce perfect occlusions but can considerably reduce the need for orthodontic treatment in public health care systems with limited resources (Al Nimri and Richardson, 2000, Kerosuo et al., 2008, King and Brudvik, 2010). It has been shown that interceptive orthodontics can reduce the definitive need for treatment (defined in this study as IOTN DHC grades 4 and 5), in a cohort of children eight to fifteen years of age, from 33% to 9% (Kerosuo et al., 2008).

An index for preventive and interceptive orthodontic need, IPION, has been developed (Coetzee, 1999). It allows early detection of developing malocclusion, facilitating the provision of interceptive treatment, minimizing or even eliminating the need for complex treatment. One study looked at the need for preventive and interceptive treatment in six and nine year olds using IPION and found 28% to have a need for treatment (Karaiskos et al., 2005). This compares favourably with the work by Al Nimri and Richardson (2000), who studied nine and eleven year olds, and found the need for interceptive orthodontics to be 33%.

It can be seen, therefore, that there is evidence in support of the need for interceptive orthodontics to reduce the need for complex treatment later, benefitting both patients and health care providers. There is the potential to change the provision of orthodontics significantly in the UK, which makes this an important area for research, with GDPs playing a pivotal role in this arrangement.

## **1.2 Aims and Hypotheses**

The focus of the research question is on the evidence to support IO treatment methods; determining GDPs attitudes and beliefs regarding IO, and what steps could be taken to improve GDPs provision of care in this area, and the potential financial impact of this.

### **1.2.1 Aims**

This thesis reports a series of studies, the aims of which were:

1. To systematically review evidence in areas where it was currently not reviewed;
2. To investigate GDPs attitudes, beliefs and knowledge surrounding IO;
3. To investigate potential cost savings of implementing IO in primary care;
4. To design an interventional study to translate these findings into practice.

### **1.2.2 Hypotheses**

The specific hypotheses relate to aims 2 and 3 above:

- Dentists possess the;
  - attitudes to provide IO in primary care,
  - beliefs to provide IO in primary care,
  - knowledge to provide IO in primary care.
- There is a cost saving to be made;
  - To NHS Tayside of increased provision of IO in primary care,
  - To NHS Scotland of increased provision of IO in primary care.

The research undertaken to address the aims stated above include:

1. A Cochrane review looking at interventions for the cessation of pacifier or digit sucking habits in children;
2. A systematic review on the management of anterior crossbites in children;
3. Semi structured interviews with a small group of GDPs to help formulate a paper based questionnaire to investigate what the barriers are to providing interceptive orthodontics in primary care;
4. Development of a paper based questionnaire sent to 400 GDPs across Scotland, with results analysed to help determine what may influence the implementation of interceptive orthodontics in primary care;



5. A cost analysis of providing interceptive treatment for children with a digit sucking habit in primary care, compared with orthodontic treatment at a later date in secondary care; and,
6. Development of a protocol for an interventional study to increase the provision of interceptive orthodontics in primary dental care.

It is the findings of these six pieces of work on which this thesis reports, following the overview of the literature presented in the next Chapter.

## **Chapter 2**

### **Overview of the Literature**

## 2.1 Introduction

Interceptive orthodontics is a term that is used to encompass many treatments for different anomalies arising in the developing dentition, and in this literature overview each will be considered individually. The quality of the literature varies considerably for each of the anomalies, but there are Cochrane reviews already in existence for the management of some conditions. Each will be explored with regards to the incidence, aetiology, diagnosis, and management. This overview does not extend to include patients with a history of cleft lip and / or palate or any other craniofacial abnormality or syndrome.

## 2.2 Anterior crossbite

Anterior crossbite occurs when one, or more, lower incisor teeth occlude anterior to the upper incisor teeth. If left untreated it can cause attrition to the labial surface of the upper incisor, fractures or mobility of incisor teeth, gingival recession or temporomandibular joint dysfunction (Harrison et al., 1991, Jones and O'Neill, 1996, Huand and Brunsvold, 2005, Jirgensone et al., 2008, Seehra et al., 2009). The incidence of anterior crossbite in children is 1 to 8% (Schopf, 2003, Stahl and Grabowski, 2003, Lux et al., 2009) and it usually becomes apparent during the early mixed dentition. It can be divided into three categories, depending on the aetiology;

- Dental malposition – the crossbite is due to one or more of the upper incisors being retroclined because of:
  - a retained deciduous tooth and subsequent palatal eruption of the permanent incisor;
  - trauma to the primary incisors resulting in displacement of the permanent successor;
  - presence of supernumeraries; or,
  - crowding.
- Functional anterior crossbite / “pseudo” class III, where the teeth meet edge to edge and in order to get the posterior teeth to occlude the patient has to posture the lower jaw forwards resulting in the anterior crossbite (Rabie and Gu, 2000). This functional mandibular shift can lead to temporomandibular dysfunction (TMD), and has been reported to alter patients' growth pattern to skeletal class III (Elling Berg et al., 2008, Ngan et al., 1988).

- Skeletal anterior crossbite / “true” class III, which depending on the severity of the underlying skeletal problem, may or may not be possible to correct with orthodontic treatment. Predicting future mandibular growth is difficult and, therefore, orthodontic treatment to correct a skeletally based anterior crossbite may relapse with further growth.

There are multiple case reports in the literature demonstrating various techniques to correct an anterior crossbite, but there was no high quality review in this area. It was, therefore, decided to undertake such a review, to identify the most effective treatment modality which involves an appliance that is easily fitted, requires minimal patient co-operation and gives rapid correction of the crossbite. This review is reported separately in Chapter 4.

### **2.3 Posterior crossbite**

Posterior crossbite can occur in the premolar or molar region, with one or more teeth involved. For the purpose of this literature review, only unilateral buccal crossbites with displacement are considered, as these crossbites have been thought to be associated with temporomandibular dysfunction (TMD) (Tecco et al., 2011, Thilander and Bjerklin, 2012). However, a recent publication concluded that posterior unilateral crossbites do not appear to be a risk factor for temporomandibular joint clicking, at least in young adolescents (Farella et al., 2007), but they only investigated clicking, which is only one of the symptoms of TMD. The incidence of posterior crossbites varies between 8 to 22% in children in the deciduous and early mixed dentition (Petrén et al., 2003). The purpose of treatment is usually to expand the maxillary arch, to correct the crossbite, and eliminate the mandibular displacement, as the aetiology is normally due to a narrow maxillary arch.

A Cochrane review entitled “Orthodontic treatment for posterior crossbites” (Harrison and Ashby, 2001, updated 2008) identified five randomised controlled trials and eight controlled clinical trials for inclusion.

There was a variety of treatment types:

- bonded versus banded rapid maxillary expansion (RME);
- trans-palatal arch (TPA) with and without buccal root torque;

- grinding of deciduous teeth with and without expansion with an upper removable appliance (URA);
- banded and bonded slow maxillary expansion;
- quadhelix (QH); and
- two or point four Hyrax expansion.

However, only two trials achieved significant results (Thilander et al., 1984, Lindner, 1989). Thilander et al. (1984) compared interceptive treatment in the deciduous and early mixed dentition in children with posterior crossbite in contrast to non-treatment. Half of the group of children with posterior crossbite were treated early. Treatment started at five years of age with grinding of the teeth and, in the event of unsatisfactory results, a URA to expand the arch. The other half were monitored and were not treated until 13 year of age. A group of children with excellent occlusion were included in the study as a comparison group. All the children were followed to 13 years of age. Of the 33 children treated early, only nine showed correction of the crossbite after grinding treatment. The subsequent interceptive treatment with URAs resulted in correction of the crossbite in a further 17 children. Of the 28 children where no corrective treatment had been performed during the observation period, six showed spontaneous correction of the crossbite. Four children in the comparison group developed a crossbite. This study concluded by recommending starting treatment of posterior crossbite by grinding the deciduous teeth, in particular the mandibular canines. If this is not effective, an orthodontic appliance, preferably a fixed quadhelix, should be applied in the early mixed dentition.

Lindner et al. (1989) investigated the effects of early interceptive grinding (of premature contacts) and the possibility of self-correction of the crossbite. Seventy six four year old children with a unilateral crossbite were divided into an intervention and a control group. The results demonstrated that 50% of the children who had undergone tooth grinding, when evaluated in the mixed dentition at nine years of age, had correction of the crossbite. In the untreated group only 17% showed a spontaneous correction of the crossbite. The authors concluded that the results of this study support early treatment of unilateral crossbite by means of grinding the deciduous canine teeth.

From the available evidence it would seem that grinding of deciduous teeth to remove occlusal interferences is one effective treatment option. Alternatively, the

provision of a quad helix to provide maxillary arch expansion is also effective if provided in the mixed dentition. However, as highlighted in the Cochrane review (Harrison and Ashby, 2001) and another systematic review (Petrén et al., 2003), the evidence is limited due to many of the studies in this area having a small sample size, bias and confounding variables, lack of blinding in measurements, and deficient statistical methods. Both groups of authors feel that to obtain reliable scientific evidence, better conducted randomised controlled trials (RCTs) with sufficient sample sizes are needed to determine which treatment is the most effective for early correction of unilateral posterior crossbite. Future studies should also include assessments of long-term stability as well as analysis of costs and side effects of the interventions.

Since the publication of these reviews, Petré and co-workers (Petrén and Bondemark, 2008) have conducted an RCT, addressing many of the previously raised concerns in the review. This study compares and evaluates the effectiveness of different treatment strategies to correct unilateral posterior crossbite in the mixed dentition. The patients were randomized into four groups: quadhelix, URA, composite onlay, and untreated control. The quadhelix appliance was superior to the expansion plate in success rate and treatment time. Treatment with the expansion plate was unsuccessful in one third of the subjects. Crossbite correction with composite onlay in the mixed dentition was ineffective, and spontaneous correction in the mixed dentition did not occur. They concluded that if unilateral posterior crossbite is planned to be corrected in the mixed dentition, treatment with the quadhelix is an appropriate and successful method. The same authors have since published three year follow up results (Petrén et al., 2011), and have shown that there is similar long term stability regardless if the crossbite is successfully corrected by the quadhelix appliance or the expansion plate. However, in treated patients, mean maxillary widths never reached those of normal control subjects. From this recent evidence it would appear that a quadhelix is the preferred treatment modality.

## **2.4 Impacted maxillary permanent central incisors**

Maxillary permanent central incisors usually erupt around the age of six to seven years, and prior to the eruption of maxillary permanent lateral incisors. Any delay in eruption or abnormality in eruption sequence should be viewed with suspicion, and

investigated. The two main causes for non-eruption of the permanent incisors are trauma to the deciduous dentition, or supernumerary teeth blocking the path of eruption for the permanent teeth (Johnsen, 1977). Another cause of failure of eruption is crowding, but this occurs less often, with the management being space creation after which 75% of incisors erupt spontaneously. Of these, 55% will align spontaneously, while the rest will require some form of orthodontic alignment (Di Biase, 1971). The incidence of an unerupted permanent maxillary central incisor in the five to twelve years of age group has been reported as 0.1% (MacPhee, 1935), and in a referred population to regional hospitals the prevalence has been estimated as 3% (Di Biase, 1969). It has been reported that maxillary incisors which fail to erupt, due to the presence of supernumerary teeth, have a better prognosis than unerupted incisors which present with a different aetiology (Betts and Camilleri, 1999).

If there is a history of trauma, it seems reasonable to expect that this will have been noted by the GDP and, therefore, there will be a heightened awareness of the possibility of eruption problems. Trauma can lead to:

- loss of vitality of the deciduous incisor, which can lead to the formation of fibrous tissue, creating a barrier to eruption (Ash, 1957). The reported prevalence of traumatic injuries to the deciduous dentition ranges from 11 to 30% (Yeung et al., 2003). A study of 41 dilacerated unerupted maxillary central incisors revealed that 22% had a history of trauma to the deciduous predecessor (Stewart, 1978).
- intrusion of the deciduous incisor (29%) (Do Espirito Santo Jacomo and Campos, 2009) which in turn damages the unerupted developing permanent incisor, leading to dilaceration. Dilaceration can occur in permanent incisors as a result of trauma to deciduous teeth whose apices lie close to the permanent tooth germ;
- avulsion of the deciduous incisor (14%) (Do Espirito Santo Jacomo and Campos, 2009), which can again damage the developing permanent incisor, leading to hypoplasia or dilacerations.

It is emphasized that radiographic examinations of all children who present clinically with evidence of delayed permanent tooth eruption, or temporary tooth displacement (with or without a history of trauma) should be performed (Batra et al., 2004). As

technology has advanced, the use of cone beam computed tomography (CBCT) appears now to be favoured as an additional diagnostic tool in some cases of impacted teeth in the mixed dentition (Nurko, 2010).

Genetic factors contribute to the aetiology of supernumerary teeth as evidenced by heritability studies and confirmed by a consistent male predilection (Niswander and Sugaku, 1963, Gallas, 2000, Gunduz et al., 2008). Mesiodens, supernumeraries in the midline of the palate, have the greatest effect on delayed eruption of permanent incisors with one study reporting incidence of 39% uneruption, compared to 18% of patients displaying a diastema due to the mesiodens (Gunduz et al., 2008). The incidence of mesiodens is 0.45% in Caucasians (Hurlen and Humerfelt, 1985). The complications associated with mesiodens not only include lack of eruption of permanent teeth but also the deviation of the eruption path, rotations, retention, root resorption and pulp necrosis with loss of vitality, and a diastema (Giancotti et al., 2002). It is important that early detection of mesiodens is successful if such complications are to be avoided.

One study found that 64% of cases where the supernumerary was surgically removed resulted in spontaneous eruption of the unerupted incisor (Smailiene et al., 2006). However, this is dependent on the incisor not being deeply impacted. The authors recommended that a maxillary central incisor impacted at the level of the apical third of the contralateral completely erupted central maxillary incisor, as viewed on an orthopantomogram (OPT), should be treated by the surgical-orthodontic approach, as spontaneous eruption is unlikely to occur. Non-erupted permanent maxillary incisor teeth with near complete apical formation, associated with unerupted palatally placed mesiodens, may benefit from having an orthodontic bracket and gold chain placed at the same time as the surgical procedure to remove the supernumerary tooth to facilitate future orthodontic traction (Foley, 2004).

The Royal College of Surgeons of England has published guidelines on the management of unerupted maxillary incisors (Yaqoob et al., 2010). However, these guidelines are based on the limited available evidence, which consist of no controlled trials, 23 retrospective case studies and 4 epidemiological studies, and other low grade evidence. Recommendations from these guidelines are divided into different age groups.

In children up to nine years of age with incomplete root development of permanent incisor the following is advised:



- Remove the obstruction;
- Do not uncover bone from the unerupted incisor – maintain integrity of the follicle;
- Create space if required;
- Monitor eruption for 18 months (80% erupt spontaneously);
- If exposure is required, expose minimally to eliminate soft tissue obstruction; and,
- If the tooth is still high, expose and bond bracket.

Children above nine years of age, with complete or nearly complete apex:

- Remove the obstruction;
- Create space if required;
- If the permanent incisor is high monitor eruption for 12 months; and
- If the tooth is still unerupted at 12 months, expose and bond bracket as required.

Children referred late (over 10 years of age):

- Remove the obstruction, expose and bond bracket at first operation.

Although these guidelines are based on limited evidence, they at least give the GDP a recommendation for management of the child, and are clearly divided into different stages of development of the central incisor. However, it may also be appropriate to stress the importance of maintaining space, awaiting the eruption of the central incisor, following the loss of the deciduous central incisor, rather than highlighting the possible need to create space. Also, it may be easier for the clinician if the guidelines were divided into cases relating to trauma and those relating to supernumeraries.

## **2.5 Ectopic maxillary permanent canines**

The incidence of impacted maxillary permanent canines has been reported as 2%, with more than 60% of these being palatally positioned (Ericson and Kurol, 1986, Stivaros and Mandall, 2000). The aetiology appears to be multifactorial, with links to small or developmentally absent lateral incisors (Brin et al., 1986), family

history/genetics (Peck et al., 1994), and increased incidence in Class II division 2 malocclusions (Mossey et al., 1994), among other factors.

In the late 1980's Ericson and Kurol investigated the effect of extraction of the deciduous canine on the ectopic permanent canine, in uncrowded mouths, in children aged 10 to 13 years. Seventy eight percent of canines were found to normalise their position within one year (Ericson and Kurol, 1988). A further study was carried out by Power and Short (1993) which involved extraction of deciduous canines in crowded mouths, with 62% of canines normalising their path of eruption. Further studies have been reported in the literature and there has been a Cochrane review published on this subject (Parkin et al., 2009). This identified two randomised controlled trials (Leonardi et al., 2004, Baccetti et al., 2008). However, these studies were excluded as the data was not presented in a form that was usable. Both studies investigated the effect of creating space in the arch for the ectopic canine. Leonardi et al. (2004) compared a group of children who had extraction of the deciduous canine, with those who had extraction plus headgear, both groups compared to a control. The results showed extraction only produced 50% success, whereas extraction plus headgear improved the success rate to 80%. The Baccetti et al. (2008) study comprised two intervention groups (extraction group, and extraction with headgear group) plus a control group, and produced even higher success rates: 65% success with extraction of deciduous canine; and, 88% success with extraction plus headgear, when compared to the control.

The Cochrane review concluded that there is insufficient evidence to support the extraction of deciduous maxillary canines to facilitate the eruption of palatally ectopic permanent canines. However, it stated that there is “a suggestion from the literature that extraction of the deciduous canine may help eruption of the permanent canine.”

Since the publication of the Cochrane review, Baccetti et al. (2009) have continued to investigate the interceptive management of ectopic maxillary canines. A randomised clinical trial was performed, using rapid maxillary expansion as the intervention (n=32), versus a no treatment control group (n=22). The participants were aged seven to nine years of age, with one or two palatally ectopic maxillary canines. The results revealed 21 subjects in the RME group had successful eruption of their canine(s), and three subjects in the control group had successful eruption of their canine(s). However, there was no mention in the study about how patients were

randomised, or use of a power calculation to determine the sample size. The authors used a posteroanterior cephalogram to diagnose the ectopic canines, a method not commonly used, and some of the patients are very young to be making this diagnosis (age range 7.6 to 9.6 years). Finally, there was no mention regarding patient tolerance of the RME, which was in situ for over six months, and was followed by a retainer for a year. Therefore, this study is incomplete, and the results have to be viewed with caution. Reflecting on referrals I see in my place of work from GDPs regarding children who have ectopic maxillary canines, most children are over 10 years of age, so there is doubt as to whether this treatment would be appropriate in the UK NHS setting.

A further study involving RME and palatally displaced ectopic canines (PDCs) has been published by Baccetti and colleagues (Sigler et al., 2011). This study compared RME followed by placement of a transpalatal arch (TPA), and extraction of deciduous canines compared with no treatment. Age range at the start of treatment was nine and a half to thirteen years of age, and diagnosis was from an OPT radiograph. In the treatment group 79% had successful eruption of their PDCs, and in the control only 28% had eruption. Successful eruption was defined as a canine which had erupted allowing the placement of a bracket on its crown, without the need for surgical intervention. Once again, this study had no mention of any randomisation technique, which may have introduced considerable bias. The design of the study could have been improved by having two more groups, one who received extraction of deciduous canines only, and one who had a TPA and extractions. This would have enabled the effect of the RME to be better investigated, as the success of eruption may have been due to extractions, or the RME, or the TPA, or a combination. Hence, it is difficult in the treatment group to identify what caused the marked increase in eruption of the PDCs.

The study published in 2011 (Baccetti et al., 2011) goes some way to improve on the design of the previous study. In this paper there were four groups; a group which received RME/TPA/extraction of deciduous canines, a group who received a TPA and extractions, an extractions only group, and a no treatment control group. The prevalence of eruption was found to be 80%, 79%, 63% and 28% respectively in each of the groups. Yet again, there was no discussion on randomisation technique. It would also appear that the subjects who received RME/TPA and extractions, and the control group, were the same subjects who were in the previous study (Sigler et

al., 2011), inferring that randomisation did not take place in this study. With these flaws in mind the conclusions that can be drawn from the results have to be considered carefully.

The final paper in the series by Baccetti and co-workers (Armi et al., 2011) compared the effect of RME and cervical pull headgear (HG) on the eruption of PDCs. There were three groups in this study, RME/HG, HG and an untreated control group. Successful eruption occurred in 86% of the RME/HG group, 82% of the HG group and 36% of the control group. There was no mention of failure to comply with treatment which is surprising as the inclusion criteria has an age range for recruitment from eight to thirteen years of age, and the subjects were expected to wear the HG 12 to 14 hours a day, for a year. Also of note, the success of eruption in the control group was higher in this study than in the previous studies, despite similar inclusion criteria.

Investigating the effect of extractions only on ectopic canines, two studies have been performed looking at the effect of extraction of the deciduous canine plus deciduous first molar, compared with extraction of only the deciduous canine (Giulio et al., 2010, Bonetti et al., 2011). The RCT by Giulio et al. indicated the double extraction approach to be a more effective treatment in improving permanent maxillary canines' intraosseous position, but the clinical success rates of eruption of the permanent canine, showed no statistically significant difference. The RCT by Bonetti et al. found that in the group who had only the deciduous canine(s) extracted, 79% of permanent canines had a favourable outcome, compared with 97% of canines in the group who had extraction of deciduous canine and deciduous first molar. A favourable outcome was determined as an uneventful canine eruption. It is possible that the results from this study could be added to the Cochrane review, but there is no control group with patients with ectopic canines who received no intervention. From the literature it would appear that creating space for the ectopic canine increases its chance of eruption whether that be by extractions (single or double), or by arch expansion, or a combination.

## **2.6 Poor prognosis first permanent molars**

First permanent molars (FPMs) have the poorest long term prognosis of all permanent teeth due to their susceptibility to caries in childhood, and their

association with molar incisor hypomineralisation (Batchelor and Sheiham, 2004, Albadri et al., 2007). It is important to consider the long term prognosis of these teeth, and, where appropriate, their extraction at the optimum time. If there is to be forced extraction of FPMs, ideal timing can lead to an acceptable occlusion (Thilander and Skagius, 1970, Koch et al., 1987), with successful mesial migration of the second permanent molars.

There is a national guidance document, produced by the Royal College of Surgeons of England, available to GPs, which assists with treatment planning when considering extraction of FPMs in children (Cobourne et al., 2009). It stresses the importance of timing of the extraction of the lower FPM, with the timing of the upper extractions being less crucial. It is advocated that the lower FPM should ideally be extracted when there is radiographic evidence of early dentine calcification within the second molar root bifurcation. This usually occurs within a chronological age range of eight to ten years (Thilander and Skagius, 1970, Thunold, 1970).

These current clinical guidelines discuss compensating extractions, and recommend extraction of the upper FPM if extraction of the lower FPM is required in Class I malocclusions. This is to prevent the theoretical risk of the upper FPM over erupting and preventing the lower second molar from drifting forward. The guidelines also discuss extraction patterns with Class II and Class III malocclusions. In a Class II malocclusion space is often required to reduce the overjet, and extractions can provide the space. However, following extraction of upper FPMs the second molars quickly mesialise, and utilise the space, resulting in no space for correction of the malocclusion. If the upper FPMs are to be lost in Class II cases, consideration should be given to allowing the second molars to erupt first before extractions. The advice given with respect to Class III malocclusions, is that upper FPM extraction should be avoided where possible.

Having examined the evidence upon which these guidelines are based, it would appear that the work by Holm (1970) is used as the main source for supporting compensating extractions. This work reviewed 1,119 cases involving loss of one or more FPMs over a ten year period, and was carried out principally to assess the proportion of cases involving loss of FPMs, and the patterns of extraction. It reported that the poorest outcomes following orthodontic treatment were found in cases of uncompensated extraction of lower FPMs, but there was no data presented

to support this. It is concerning to think that the guidelines for extractions of FPMs are based on this study, which took place over 40 years ago, and observed patients who had undergone orthodontic treatment, either fixed, removable or a combination. Perhaps the poor outcomes were due to the types of appliances available at the time, and not purely due to the pattern of extractions.

More recently Mejare et al. (2005) has reviewed 32 patients (mean age 18 years) who have lost of one or more FPMs in childhood (mean age 10 years) due to molar incisor hypomineralisation (MIH). Five patients had an uncompensated extraction of a lower FPM, and no-one had over eruption of the upper FPM noted. Also, Jälevik and Möller (2007) in a longitudinal study of 27 children who had one or more FPMs extracted due to MIH, reported no significant occlusal problems with the four children with uncompensated extractions of lower FPMs, and recommended against the need for compensating extractions.

From the available evidence, there is little to support compensating extractions, despite this being current recommended clinical practice. There is a clear need for randomised controlled trials (RCTs) in this area to justify additional extractions in children. An RCT is currently underway in Scotland to answer the question of the need to perform a compensating extraction when extracting a lower FPM, and the protocol to the study is available to view on line (ClinicalTrials.gov, 2012).

## **2.7 Infraoccluded second deciduous molars**

The term infraoccluded is used to describe a tooth when it is situated below the occlusal plane. There is a strong link between infraocclusion and ankylosis, an anatomical fusion of cementum with alveolar bone, which can occur at any time during the course of eruption (Owen, 1965). Due to the sinking appearance of an individual tooth, whilst normal development occurs around it, the term “submerging” is often applied. This term is incorrect as there is no actual submerging of the tooth, instead there is vertical growth of the alveolus around the deciduous tooth giving the appearance of it sinking. Ankylosed teeth may prevent eruption of the permanent successors (impaction), or deflect the path of eruption (Andlaw, 1974). Other problems such as space loss with tipping of adjacent teeth or over eruption of opposing teeth can occur (Andlaw, 1974, Konstat and White, 1975). The lack of movement of the deciduous tooth can lead to restricted vertical alveolar

bone deposition, possibly reducing the amount of bone surrounding the permanent successor.

Infraocclusion can occur whether there is a developing premolar or not. The prevalence of infraoccluded deciduous molars has been reported as 8 to 14% in children six to eleven years of age (Brearley and McKibben Jr, 1973, Andlaw, 1977, Krakowiak, 1978, Kurol, 1981, Koyoumdjisky-Kaye and Steigman, 1982), with an increase occurrence in Caucasians (Albers, 1986). There is variation in this figure as ankylosis is not a static condition (Kurol and Thilander, 1984b), and is also age related (Kurol, 1981), with the prevalence of infraocclusion varying between age groups, with a maximum of 14% in children eight to nine years of age and a minimum of 2% in children 12 years of age.

Previously, it had been thought that the aetiology of infraocclusion was due to extrinsic factors, such as local mechanical trauma (Adamson, 1952), or a deficient eruptive force (Dixon, 1963), but other reports have linked the condition with intrinsic factors, with a strong genetic link between siblings (Via Jr, 1964, Kurol, 1981). One recent paper states that infraoccluded deciduous second molars could be an early marker for other dental anomalies such as palatally displaced canines and tooth agenesis, both known to have a strong genetic component (Shalish et al., 2010).

Ideally, waiting for exfoliation of the deciduous molar is the best treatment, as early extraction can lead to space loss in the arch, but not all infraoccluded molars exfoliate naturally. In a longitudinal study (Kurol and Thilander, 1984a) looking at both upper and lower infraoccluded molars, 149 were monitored, and five required extraction. The authors concluded that extraction should only be performed if there is deep infraocclusion and space loss has already occurred. They also recommend using the time of exfoliation on the “normal” side of the arch as a guide to the expectation for the infraoccluded side. In a separate study where there was aplasia of the successor, the infraoccluded tooth did not exfoliate within the normal time range, and the root resorption was found to be very slow, especially after 12 to 13 years of age (Kurol, 1984).

It would, therefore, appear that the management of infraoccluded deciduous molars has two separate treatment pathways, depending on whether the premolar is present or not. If it is present it is likely that the deciduous molar will exfoliate and extraction is not usually necessary. If it is not present then extraction may be

required. However, the rest of the occlusion should be assessed before the deciduous molar is extracted as it may not be possible to close the resulting space, and keeping the deciduous tooth for as long as possible may be an option (Sabri, 2008). The paper by Kokich Jr (2005) gives some practical tips on maintaining deciduous second molars during orthodontic treatment.

It has been noted that these deciduous molars can last a considerable length of time and may act as a medium term measure. A longitudinal study followed up patients who were diagnosed during the mixed dentition with missing second premolars, and had retained deciduous second molars. Of the patients who returned 15 years later for examination (18 patients, 26 teeth), it was found that the degree of root resorption was unaltered in 20 of the 26 deciduous molars. Three of the six remaining deciduous molars had been extracted due to caries, and three showed extensive resorption. Of note, none of the teeth were mobile, the teeth that were in infraocclusion were ankylosed, no neighbouring teeth were tilted, and no opposing teeth had over-erupted (Ith-Hansen and Kjær, 2000).

## **2.8 Malocclusion due to Non-nutritive Sucking Habits**

The term 'non-nutritive sucking habit' (NNSH) encompasses the use of pacifiers (dummies/ soothers), blankets and digit sucking. Although the incidence of sucking habits varies considerably between different countries, these comforting habits are common in children in many populations. A Swedish study looked at 60 consecutive births, and found the incidence of NNSH to be 82% during the first five months of life (Larsson, 2001). A United States based study reported the incidence as 73% for a group of 130 children between two and five years of age (Adair et al., 1992). The incidence of NNSH reduces with age. Available data has shown that around 48% of four year olds maintain a digit or pacifier sucking habit (Modéer et al., 1982), 12% of children past the age of seven years (Patel et al., 2008) reducing to 2% of children by 12 years of age (Baalack and Frisk, 1971).

Children with a history of a persistent NNSH are more likely to develop a malocclusion compared to children with no NNSH history (Bowden, 1966, Svedmyr, 1979, Fukuta et al., 1996, Farsi, 1997, Vázquez-Nava et al., 2006, Mistry et al., 2010). In addition, there is evidence that the more prolonged duration of the habit, the more severe the developing malocclusion tends to be (Baalack and Frisk, 1971,



Warren and Bishara, 2002, Singh et al., 2008). However, rather than there being a direct cause-effect relationship between NNSH and development of a malocclusion, the effects of a habit seem to be superimposed on genetic predispositions to a malocclusion. Therefore, the NNSH might worsen or, conversely, counteract an underlying malocclusion and lead to an improvement. For example, in a child who has a Class III incisor relationship, a NNSH may push the upper anterior teeth forwards, and the lower ones backwards, resulting in a less severe malocclusion. If these problems are not diagnosed until the patient is in the permanent dentition, it can be complex, time consuming and costly to correct the problem, and it will usually require orthodontic fixed appliance treatment carried out by a specialist orthodontist (Petrén and Bondemark, 2008). In severe cases it can even require orthognathic surgery to correct the anterior open bite.

The literature describes different methods for cessation, ranging from fitting an orthodontic appliance, removal of the comforting object, application of a chemical substance to the digit, or behaviour modification techniques (Al-Jobair and Al-Emran, 2004, Friman et al., 1986).

There was found to be little consensus regarding the best method for cessation of these habits, and it was decided a high quality systematic review was required to identify and consolidate the evidence regarding the most effective treatment method for cessation of these habits. This review is reported in Chapter 3.

## **2.9 Centreline shift due to unilateral loss of deciduous teeth**

The loss of a maxillary dental centreline can have aesthetic consequences, and work by Johnson et al. (1999) has shown that lay people notice a maxillary centreline shift of 2mm or more. Also, a centreline shift prevents good intercuspation in the buccal segment due to mesial drift of the segment. It can be difficult once in the permanent dentition to correct a centreline discrepancy, with often a unilateral extraction required to create space to correct the shift. It has been suggested that this shift can be prevented by extraction of the contralateral deciduous canine, around the time of loss of the first deciduous canine, known as a balancing extraction.

Many British textbooks stress the importance of balancing maxillary deciduous canines in order to preserve the midline (Mitchell, 2007, Welbury, 2005). This has been thought to be due to the high prevalence of incisor crowding in British children

(Avramaki & Stephens 1988). The deciduous canine can be lost prematurely at the time of eruption of the lateral incisor, due to crowding (McDonald and Avery, 1983), and a Finnish study reports the prevalence of early loss of deciduous mandibular canines, due to crowding, as 0.1 % (Jarvinen, 1981). The discussion paper by Hollander and Full (1992) highlights findings from the Iowa facial growth study, recording that out of approximately 200 children, 26 had a deciduous canine exfoliate due to the erupting lateral incisor. A centreline shift occurred in all of these patients, and 25 had a balancing extraction of the remaining deciduous canine. Nine of the patients still had a centreline shift in adulthood. This is an interesting finding but it is unclear if the centreline shift was clinically significant and whether these findings relate to the maxilla or mandible or both.

The incidence of centreline shift in children, due to premature unilateral loss of deciduous teeth is difficult to quantify due to the lack of published data. A British based study collected and analysed study models longitudinally from 106 children, taken annually from four to 14 years of age (Clinch and Healy, 1959). They obtained 59 sets of complete models. As part of the study they investigated the magnitude, speed and direction of space loss resulting from premature loss of deciduous teeth, including centreline shift following unilateral or bilateral deciduous tooth extractions. Twelve children had unilateral extractions of either upper or lower teeth, between the ages of four and a half and eight and a half years. Seven of the children had no alteration in centreline and three showed a temporary shift which corrected by 14 years of age. Only two of the 12 children maintained a centreline shift at 14 years of age, following a unilateral deciduous extraction. The sample size is small in this study, with no control data presented; therefore the results need careful interpretation as there is no mention as to why the extractions were performed.

Another study, carried out over 30 years ago, looked at all children nine to eleven years of age in Silkeborg, Denmark, and compared those who had had extractions with those who had not (Pedersen et al., 1978). In the non-extraction group a centreline discrepancy was noted in 17% of children, and in the extraction group the centreline discrepancy was 26%. Unfortunately, there was no information for the extraction group specifying which teeth were extracted. From this study it can be seen that centrelines may not be coincident, even if there have been no deciduous extractions.

There is little literature related to providing interceptive orthodontics in this situation, but one limited review of the literature concludes that midline corrections do not always spontaneously occur, and orthodontic treatment can potentially be carried out at a later date to correct it, when in the permanent dentition (Hollander and Full, 1992). This review appears weak as there was no mention how studies were identified, no inclusion criteria, and includes only eight references, all of which were case reports or anecdotal papers. Although there are no controlled trials in this area, a more robust search strategy would have improved this study.

A pilot study performed in the late eighties by Avramaki and Stephens (1988) aimed to quantify the effect of unilateral extraction of deciduous molars on the position of the incisor centreline. This was a retrospective study looking at study models with either an unbalanced extraction or balanced extraction, or all deciduous molars present. The results showed that the degree of centreline shift was statistically significantly different between the balanced and unbalanced extraction groups, and also between the unbalanced and no extraction groups. This study supports the theory of balancing the extraction of deciduous molars. However, the study included extraction of second deciduous molars, as well as first molars which have been shown to have less effect on centreline shift, so these results should be viewed with caution.

The evidence supporting balancing deciduous molar and canine extractions appears to be of poor quality, and not convincingly supportive of current practice and teaching in the U.K, which advocates balancing. The need for a high quality randomised control trial is emphasised, as it could be that many balancing extractions are being carried out needlessly.

## **2.10 Increased Overjet**

Altun et al. (2009) reported that children with an increased overjet are more than twice as likely to have dental injuries than other children, with the incidence of traumatic dental injury highest among children ages six, and ages eight to ten years. An increased overjet rather than a Class II malocclusion appears to be the significant risk factor for upper incisor trauma (Baccetti et al., 2010), and increased overjet and inadequate lip coverage increases the risk and severity of incisor trauma (Burden, 1995). The incidence of increased overjet has been reported as 18% in children nine

years of age in Scotland, with an increased overjet recorded as greater than 5mm (Hill, 1992). In Finland, 27% of children at the onset of the mixed dentition (range 4.0 to 7.8 years) presented with excessive overjet (recorded as  $\geq 4\text{mm}$ ) (Keski-Nisula et al., 2003).

If a child is referred at a young age, the orthodontist is faced with the dilemma of whether to treat the patient early or to wait until the child is older, and provide treatment in early adolescence. Often cases with prominent upper incisors require a two phase treatment, one to reduce the overjet, then a second to correct any other irregularities in the malocclusion, usually achieved by provision of a functional appliance followed by fixed appliances. The problem with starting treatment early is there is a time delay between stage one and two, whilst further eruption of the permanent dentition occurs. Thus, two stage treatments can be protracted, leading to a reduction in patient compliance (Tulloch et al., 1998, Tulloch et al., 2004, O'Brien et al., 2009).

A Cochrane review has been conducted with the aim being to assess the effectiveness of orthodontic treatment for prominent upper front teeth in two age groups; when the child is seven to nine years of age; or, when they are in early adolescence (Harrison et al., 2007). The review identified and included eight trials, four trials providing treatment for children who were between eight and eleven years of age, and four trials providing treatment for children who were ten to fifteen years of age. From the evidence it would appear that providing early orthodontic treatment for children with prominent upper front teeth (a functional appliance), then providing the second phase of treatment (fixed appliances) when in the permanent dentition, is no more effective, with respect to the resulting occlusion, than providing one course of orthodontic treatment when the child is in early adolescence (functional appliance followed by fixed appliances).

One circumstance which may encourage early intervention for a patient with a large overjet, is when they are being teased. The literature has shown that early treatment with Twin block appliances resulted in an increase in self-confidence and a reduction of negative social experiences (O'Brien et al., 2003). Other studies have shown this link between increased overjet and teasing/low self-esteem (Helm et al., 1985, Kilpeläinen et al., 1993, Wong et al., 2006).

## **2.11 Summary of the literature**

Having reviewed the literature for the range of malocclusions where interceptive treatment is considered, the following recommendations can be made:

1. There are Cochrane reviews for managing increased overjet, posterior crossbite, and impacted maxillary canines. Since their publication there have been further studies that may add to the conclusions in these reviews;
2. There are clinical guidelines for impacted maxillary central incisors and poor prognosis first permanent molars, but these are based on weak evidence;
3. There appears to be little evidence surrounding the best way to manage infraoccluded deciduous molar teeth, and also centreline shifts due to unilateral loss of deciduous canines; and,
4. There is some evidence surrounding the management of an anterior crossbite, and intervening with a non-nutritive sucking habit, but literature in these areas fails to provide any definitive answer.

Reflecting on this overview of the literature, there appears to be little high quality evidence with often conflicting reports on the management of the developing dentition. It is not surprising that clinicians are managing these potential interceptive situations in a variety of ways, or not at all, with the most frequent decision being referral to a specialist.

## **Chapter 3**

### **Interventions for the Cessation of Pacifier or Digit Sucking Habits in Children – A Systematic Review**

### 3.1 Introduction

The literature overview presented in Chapter 2 indicated there were numerous articles discussing various methods for the cessation of pacifier and digit sucking habits (NNSHs) but no obvious consensus within the literature. NNSHs are common, and this is a topic of significant interest to parents. It was felt there was a need to determine the most effective and timely management option(s) for cessation of NNSHs, with consideration given to those associated with the least distress for children and their parents/carers. Knowing that there was at least one RCT in this area, it was decided to conduct a systematic review, following Cochrane methodology. The aim of this review was to draw together the evidence, and identify which interventions are the most successful.

### 3.2 Background

Although NNSHs do not inevitably lead to a predictable malocclusion, different sucking habits generally have different effects on the position of the teeth. A malocclusion can develop with persistence of a NNSH, through application of pressure by the object/digit on the teeth, interfering with their normal path of eruption. Prolonged pacifier habits are associated with the development of posterior crossbites, and prolonged digit habits with increased overjet (Ogaard et al., 1994, Warren and Bishara, 2002, Bishara et al., 2006). Both are associated with an increased prevalence of reduced overbite and anterior open bite (AOB) (Warren and Bishara, 2002). Children with an increased overjet and incompetent lips (often associated with an anterior open bite) are at greater risk of dental trauma, due to the prominence of the upper teeth and lack of protection from the lips (Bauss et al., 2004, Baldava and Anup, 2007). Incompetent lips and prominent upper anterior teeth are both associated with poor facial aesthetics.

Speech can also be affected by tooth position. Laine et al. (1987) found a significant relationship between increased overjet and distortions of the “s” sound. Bernstein (1954) noted speech is commonly defective where there is an AOB, often presenting with a lisp. There have also been reports of digit deformities developing as a result

of prolonged digit sucking, on occasion requiring surgical correction (Reid and Price, 1984) although these are rarely reported.

If a NNSH continues while the permanent dentition is establishing, it may be associated with a malocclusion which will require treatment with fixed orthodontic appliances. This results in time consuming, complex and costly treatment usually carried out by a specialist orthodontist (Petrén and Bondemark, 2008). In severe cases, orthognathic surgery is required to correct an AOB.

A number of different interventions have been described in the literature to assist the child who wishes to stop the habit, and to support parents who seek advice on this. However, it is not known which is most effective or even if they are effective, or which are favoured by children and parents.

### **3.3 Description of the intervention**

A wide variety of different approaches and interventions have been described which range from removal of the comforting object, through fitting an orthodontic appliance to directly interfere with the habit, application of an aversive tasting substance to the digit, to behaviour modification techniques (Friman et al., 1986, Al-Jobair and Al-Emran, 2004). Some of the interventions are easier to apply than others, less disturbing for the child and their parent or carer, and certain approaches are likely to be more applicable to a particular type of habit.

The interventions are likely to differ with respect to their:

- effectiveness in habit cessation;
- ease with which children cope, and ease of implementation from a parent/carer perspective;
- time to stop the NNSH;
- reduction in severity of the malocclusion: and,
- cost of treatment



### **3.4 How the intervention might work**

The way in which the intervention might work depends on the habit, and the type of intervention. Where the habit involves an object (blanket, pacifier etc), its removal will stop the habit (or lead to it being replaced by another). For habits involving digit sucking, there are a number of different types of intra-oral appliances to prevent placement of the digit in the habit position. Other appliances prevent the sense of gratification the child feels through carrying out the habit, although the digit can still be sucked. Other approaches involve replacing the feeling of comfort with an unpleasant stimulus, such as an aversive taste. Behavioural modification techniques such as cognitive behavioural therapy, reward-based strategies, or use of positive reinforcement can also be employed to create a behaviour change.

### **3.5 Objectives**

Primary objective: To evaluate the effectiveness of different interventions for cessation of non-nutritive sucking habits in children.

Secondary objectives:

1. To determine which interventions work most quickly;
2. To determine which interventions provide least discomfort and psychological distress to the child, from a child and parent/carer perspective; and,
3. To determine which intervention is most successful in reducing the severity of the malocclusion (reduction in AOB, overjet, and correction of posterior crossbite).

## **3.6 Methods**

### **3.6.1 Types of studies**

Randomised controlled clinical trials and quasi-randomised controlled clinical trials, comparing an intervention for cessation of non-nutritive sucking habits, with either a different intervention(s) or no treatment or control will be included.

### **3.6.2 Types of participants**

Children who have:

- (A) a digit sucking habit; or
- (B) any other NNSH, including a pacifier (dummy) habit.

### **3.6.3 Types of interventions**

For participant group A the following was considered:

- orthodontic appliances;
- barrier techniques - gloves/plasters etc.;
- chemical techniques - topical substances applied to digit;
- behaviour modification techniques;
- non-treated control; and,
- any combination of the above.

For participant group B the following was considered:

- pacifier withdrawal;
- orthodontic appliances;
- chemical techniques - topical substances applied to pacifier;
- behaviour modification techniques;
- non-treated control; and,

- any combination of the above.

#### **3.6.4 Outcome measures**

The primary outcome measure was cessation of the habit.

The secondary outcomes related to:

1. Time taken for intervention to be effective;
2. Child and parent/carer centred outcomes of discomfort from the intervention, psychological effects of teasing associated with the intervention, and distress caused by removal of the comfort/habit; and,
3. Reduction in malocclusion as measured by:
  - reduction in anterior open bite (mm);
  - reduction in overjet (mm); or,
  - correction of posterior crossbite.

#### **3.6.5 Search methods for identification of studies**

The search strategy was developed to identify all randomised and quasi-randomised clinical trials dealing with the subject of this review. Detailed search strategies were developed for each database searched based on the search strategy developed for MEDLINE (OVID) and are presented in Appendix 1. This subject strategy was revised appropriately for each database to take account of differences in controlled vocabulary and syntax rules. The MEDLINE search strategy combined the subject search with the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomised trials in MEDLINE. The subject search used a combination of controlled vocabulary and free text terms. The search strategy was not limited to children in order to avoid missing studies which included both adults and children. The search was developed with the help of the Cochrane Oral Health Group. The following databases were searched:

- Cochrane Oral Health Group's Trials Register (to 26<sup>th</sup> March 2012);

- Cochrane Central Register of Controlled Trials (CENTRAL) (*The Cochrane Library* 2012, issue 1);
- MEDLINE via OVID (1966 to 26<sup>th</sup> March 2012);
- EMBASE via OVID (1980 to 26<sup>th</sup> March 2012);
- PsychINFO via OVID (1920 to 26<sup>th</sup> March 2012);
- CINAHL via EBSCO (1981 to 26<sup>th</sup> March 2012).

The following journals were identified as being potentially important to be hand searched for this review; American Journal of Orthodontics and Dentofacial Orthopedics, Angle Orthodontist, ASDC Journal of Dentistry for Children, British Dental Journal, European Journal of Orthodontics, International Journal of Paediatric Dentistry, Journal of Orthodontics. The Cochrane Master List of Journals was consulted (March 2011) and showed searching to be complete for the following dates:

- American Journal of Orthodontics and Dentofacial Orthopedics, 1970 to 2004;
- Angle Orthodontist, 1979-2006;
- ASDC Journal of Dentistry for Children, 1948 to 2003;
- British Dental Journal, 1958 to 2007;
- European Journal of Orthodontics, 1979 to 2005;
- International Journal of Paediatric Dentistry, 1991 to 2007; and,
- Journal of Orthodontics, 1973 to 2007.

Hand searching was not carried out as it was decided that it was unlikely that any new studies would be present in the years from the completed searches to 2008, when hand searching formally started, and contacting authors of included studies for any additional information was considered to be more effective. Databases were searched with no language exclusions, however all articles found were in English or provided an English abstract. The first named authors or corresponding authors of studies included in the review were contacted in an attempt to identify unpublished

studies, and to obtain any further information about the trials. There was a response from only one author (Larsson) who was not aware of any other studies. The reference lists of all publications identified were checked for further relevant studies.

### **3.7 Data collection and analysis**

#### **3.7.1 Selection of studies**

Two reviewers (Felicity Borrie (FB) and Nicola Innes (NI)) independently, and in duplicate, assessed the titles and abstracts of all reports identified by the search strategy for relevance to the review. Full copies of all relevant and potentially relevant studies, which appeared to meet the inclusion criteria, or for which there was insufficient data in the title and abstract to make a clear decision, were obtained. A third reviewer (David Bearn (DB)) assisted with study selection where there was doubt about the inclusion of a trial. All studies excluded, and the reasons, were noted.

#### **3.7.2 Data extraction and management**

For studies meeting the inclusion criteria, a risk of bias assessment was undertaken, and data extraction was carried out. Studies rejected at this or subsequent stages were recorded. Two reviewers (FB and DB) independently and in duplicate extracted data on a specially designed data extraction form (Appendix 2). Consensus was reached for all data included and any disagreements were resolved by the third reviewer (NI). For each trial the year of publication, country of origin and source of study funding were recorded as well as:

1. Trial methods
  - Method of allocation
  - Proportion of losses at follow-up
2. Participants
  - Age
  - Gender
  - Sample size

### 3. Intervention

- Type
- Duration, and duration of follow-up

### 4. Control

- Type of control
- Duration, and duration of follow-up

### 5. Outcomes

- Primary and secondary outcomes as described in the outcome measure section of this protocol.

#### **3.7.3 Assessment of risk of bias in included studies**

For the studies included in this review, assessment of risk of bias was undertaken independently and in duplicate by two reviewers (FB and NI). An overall risk of bias judgment was obtained for each study by addressing six specific domains: sequence generation, allocation concealment, blinding (because of the nature of the interventions this was only potentially possible for the outcome assessors), completeness of outcome data, risk of selective outcome reporting and other potential sources of bias. For each entry within the domains, the reporting in each study was examined, and a judgment made of the risk of bias for that entry (Table 3.1).

#### **3.7.4 Measures of treatment effect**

For ordinal data, including patient centred outcomes, discomfort and psychological effects, these were, as appropriate, dichotomised and then risk ratios (RR)s were calculated.

For dichotomous data, including cessation of habit and correction of crossbite, RRs and their 95% confidence intervals and number needed to treat (NNT) would have been calculated if data had been available.

For continuous data, including reduction in habit (measured in hours per day), time to cease habit (measured in days), overjet and overbite (measured in millimetres), the mean difference and 95% confidence intervals would have been calculated if data was available.

For counts, including appliance breakages, it was planned to calculate the rate ratio for each appliance type, but there was no data available so this was not calculated.

### **3.7.5 Unit of analysis issues**

Randomised clinical trials and pseudo-randomised clinical trials were included. For studies where repeat measurements were carried out, data would have been analysed at six months and twelve months after commencement of the intervention. However, this was not done as the interventions were applied for various lengths of time, and the outcomes measured varied amongst the trials.

### **3.7.6 Dealing with missing data**

Following evaluation of the studies not all patients were accounted for. Two studies had one drop out (Haryett et al., 1967, Larsson, 1972). In the study by Haryett et al. one patient moved away from the area, and was not followed up, and in the Larsson study one patient did not wish to continue participating in the study. The study by Azrin et al. (1980) had a considerable reduction in numbers during the follow up period, allowing only the data recorded at three months follow up to be used. The analysis was not performed on an intention to treat basis with no allowance for incomplete data. An attempt was made to contact the authors but there was no response.

### **3.7.7 Assessment of heterogeneity**

Clinical heterogeneity was assessed by examining the characteristics of the studies, the similarity between the types of participants, the interventions and the outcomes, as specified in the criteria for included studies. Statistical heterogeneity was to be assessed using a  $\text{Chi}^2$  test and the  $I^2$  statistic where  $I^2$  values over 50% indicate substantial to considerable heterogeneity. Heterogeneity would have been considered to be significant when the P value was less than 0.10 (Higgins and Green, 2011). However, there was insufficient data for this calculation to be performed.

## 3.8 Results

### 3.8.1 Description of studies

A detailed description of the studies can be found in Appendix 3.

### 3.8.2 Results of the search

There were 183 publications identified from the search strategy, and 164 were excluded after reviewing the titles and abstracts. No further potentially eligible studies were identified from the references checked. Full text articles were obtained for the remaining 19, all of which were in English language. Of these 19 studies, 13 were excluded as they were not randomised or quasi-randomised controlled trials (RCTs). Therefore, six RCTs (Haryett et al., 1967, Larsson, 1972, Azrin et al., 1980, Christensen and Sanders, 1987, Friman and Leibowitz, 1990, Villa, 1997) fulfilled all the criteria for inclusion and have been included in the review. The trials were conducted in the USA (Azrin et al., 1980, Friman and Leibowitz, 1990, Villa, 1997), Canada (Haryett et al., 1967), Sweden (Larsson, 1972) and Australia (Christensen and Sanders, 1987), and included a total of 252 enrolled participants. The sample sizes ranged from 22 (Friman and Leibowitz, 1990) to 76 patients (Larsson, 1972) and there were no descriptions of power calculations for any of the studies. Two studies did not give clear inclusion criteria for the participants (Azrin et al., 1980, Villa, 1997). Details of the participants' age range were given for four studies (2 ½ years to 18 years of age). The mean ages of the participants were:

- 8.3 years of age (range 2.5 to 14 years)(Azrin et al., 1980),
- 6.3 years of age (range 4 to 9 years)(Christensen and Sanders, 1987),
- 6.4 years of age in the intervention group, 6.8 years of age in the control group (range 4.0 to 11.6 years)(Friman and Leibowitz, 1990),
- 12.1 years of age in intervention group, 13.5 years of age in the control group (range 8 to 18 years)(Villa, 1997).

One study stated the participants were four years of age and over (Haryett et al., 1967), and another that the participants were nine years old (Larsson, 1972).



There were variations in both the control and intervention comparisons in the trials. Two of the studies investigated a single intervention versus a control group (Friman and Leibowitz, 1990, Villa, 1997); one compared two intervention groups with a control group (Christensen and Sanders, 1987); another had three intervention groups and a control group (Larsson, 1972) and in one study there were five intervention groups and a control (Haryett et al., 1967). The sixth study (Azrin et al., 1980) compared two intervention groups.

In five of the studies, where the interventions were psychological in nature or an aversive tasting substance was applied, parents administered the interventions at the participants' home (Azrin et al., 1980, Christensen and Sanders, 1987, Friman and Leibowitz, 1990, Haryett et al., 1967, Larsson, 1972). Two studies involved orthodontic appliances which were provided in an orthodontic clinic, although whilst these were in situ, other interventions were carried out at home by the children's parents (Haryett et al., 1967, Larsson, 1972). In one study the intervention, an orthodontic appliance, was provided in an orthodontic clinic (Villa, 1997).

### **3.8.3 Interventions**

The interventions were grouped into psychological interventions, aversive tasting substance application to digits, and intra-oral orthodontic appliances. In some of the studies combinations of interventions were applied to the same individual, and the details of the interventions in the studies are grouped including the combinations.

#### *Psychological Interventions*

There were five types of psychological interventions:

- i. *Habit reversal (Azrin et al., 1980, Christensen and Sanders, 1987)*

The children were taught competing behaviours such as making a fist or grasping a convenient object for one to three minutes (measured by counting to 100). In the study by Azrin, parents were instructed to praise the child when sucking was absent, provide pleasant treats and surprises when sucking was absent for an extended period, and stop television or bedtime stories when sucking occurred.

- ii. *Differential reinforcement of other behaviour (DRO) (Christensen and Sanders, 1987)*

DRO involved an increasing schedule of reinforcement using tokens as rewards when thumb sucking was avoided.

- iii. *A two part strategy; gaining child's cooperation to break the habit and parental reward for periods of no sucking (Haryett et al., 1967)*

Co-operation was gained by creating a desire in the child to avoid negative aesthetic effects. This was done by showing the child that digit sucking could alter the position of the teeth using both their own teeth (with mirrors) and pictures/ models of other teeth with undesirable aesthetics. The second part of the strategy involved the parent rewarding the child for periods of "no sucking" by giving them their full attention and ignoring them if the habit occurred.

- iv. *Positive reinforcement (Larsson, 1972)*

Participants' mothers were given specific instructions about different forms of encouragement and reinforcement was also given by a psychologist.

- v. *Negative reinforcement (Larsson, 1972)*

Children and their parents were given information about the consequences and risks of prolonged finger sucking. They were given models of the children's teeth home with them.

#### *Aversive tasting substance application (Azrin et al., 1980)*

In one group, the parents of the children received a single phone call informing them to apply a bitter tasting substance to the digit, morning and evening.

#### *Orthodontic appliance use*

Three of the studies included in this review used two types of orthodontic appliances (palatal cribs and palatal arches) as interventions (Haryett et al., 1967, Larsson, 1972, Villa, 1997).

- i. *Palatal crib (Haryett et al., 1967, Larsson, 1972, Villa, 1997)*

Although three studies used palatal cribs, the designs of these differed between the studies. These minor differences were unlikely to have an effect on the way they work.

Haryett et al. (1967) defined a palatal crib as an appliance which had bands on either the maxillary second deciduous molars or first permanent molars. Pictures showed a stainless steel wire fitted behind the maxillary incisors, over the palatal rugae with “vertical fence-like projections extended as deep as the lateral excursions of the mandible will allow.”

Larsson (1972) used a “palatal crib,” and in this study described it as being a palatal crib with spurs welded to bands cemented to the maxillary first permanent molar teeth. “The crib lay a millimetre or so from the mucosa, and extended just behind the maxillary incisors. The spurs were rounded in front and so adjusted that they did not disturb the occlusion.”

Villa (1997) used a “palatal crib,” but does not specify the design of this appliance. He mentions in the study that he felt the appliance he fitted would have made sucking difficult, “if not impossible.” If this appliance had been a palatal arch some degree of sucking would likely have been possible. As there was no response from the authors to clarify the design of the palatal crib used, it has been assumed that this crib was similar to that used by Haryett et al.

#### *ii. Palatal arch (Haryett et al., 1967)*

The palatal arch placed in this study, had bands on the molars and a wire sitting on the gingival margins of the palatal side of the upper incisors, but had no projections. Although called a palatal arch in this study, this design is different from a standard Goshgarian palatal arch used in orthodontics, where the wire connecting the bands is situated across the middle of the palate, and has an omega loop. For the purpose of this review, when a palatal arch is referred to, it will be the design used by Haryett et al.

#### Combination treatment

There were three combination treatments.

#### *i. Palatal arch and psychological intervention (Haryett et al., 1967)*

The design of the appliance is described above, and the psychological component involved a two part strategy; gaining child’s co-operation to break the habit, and parental reward for periods of no sucking.

ii. *Palatal crib and psychological intervention (Haryett et al., 1967)*

The design of the appliance is described above, and the psychological component involved a two part strategy; gaining child's cooperation to break the habit and parental reward for periods of no sucking.

iii. *Application of an aversive tasting substance and psychology (Friman and Leibowitz, 1990)*

This involved both application of an aversive tasting substance to the thumb and a psychological component, a treat chosen at random from a grab bag.

### 3.8.4 Outcomes

Data were extracted for the primary outcome of habit cessation, and two of the secondary outcomes, child and parent/carer centred outcomes, and reduction in malocclusion.

#### PRIMARY OUTCOME

Habit cessation was measured in five studies (Azrin et al., 1980, Christensen and Sanders, 1987, Friman and Leibowitz, 1990, Haryett et al., 1967, Larsson, 1972) but in a number of different ways:

- four of the studies measured cessation of the habit by proportion of participants who had stopped their NNSH in each group (Azrin et al., 1980, Christensen and Sanders, 1987, Haryett et al., 1967, Larsson, 1972);
- one of these studies (Christensen and Sanders, 1987) additionally measured the proportion of time spent digit sucking before and after the intervention; and,
- one study (Friman and Leibowitz, 1990) only measured the percentage intervals of time with observed thumb sucking immediately after the intervention.

The times that the outcomes were measured at varied from five days (Friman and Leibowitz, 1990) to three years (Haryett et al., 1967).

#### SECONDARY OUTCOMES

1. Child and parent/carer centred outcomes

Three studies recorded child and parent/carer centred outcomes (Christensen and Sanders, 1987, Friman and Leibowitz, 1990, Haryett et al., 1967):

- upset resulting from the intervention, eating difficulty and the development of mannerisms (Haryett et al., 1967);
- change in “oppositional behaviour” from baseline to follow up. Oppositional behaviour was defined as unprogrammed, undesirable changes in behaviour, negative side effects or inappropriate behaviours. They also recorded whether parents would recommend the intervention (Christensen and Sanders, 1987); and
- acceptability of the prescribed treatment, from a parent, paediatrician and psychologist perspective, using a 7 point scale (Friman and Leibowitz, 1990).

## 2. Reduction in malocclusion

Parameters relating to change in malocclusion were measured in only one study (Villa, 1997). The measurements recorded were:

- reduction in anterior open bite (AOB); and,
- reduction in overjet and change in arch length immediately post intervention.

## 3. Time taken for the intervention to be effective

None of the studies used the same intervention for different time periods so this could not be analysed.

### **3.8.5 Risk of bias in included studies**

A risk of bias table was completed for each included study examining random sequence generation (selection bias), allocation concealment (selection bias), blinding (performance bias and detection bias), incomplete outcome data (attrition bias), selective reporting (reporting bias) and any other bias. From this a risk of bias summary table was constructed (Table 3.1).

**Table 3.1;** Reviewers' judgements about each risk of bias item, for each included study.

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding (performance bias and detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Azrin 1980	+	-	-	?	-	+
Christensen 1987	+	-	-	?	+	+
Friman 1990	+	-	-	+	+	+
Haryett 1967	?	?	?	+	+	+
Larsson 1972	+	?	-	-	+	+
Villa 1997	?	?	+	+	+	?



= yes, there was no bias present



= no, there was bias present



= unsure, insufficient information to make a decision

Four studies had a moderate risk of bias (Azrin et al., 1980, Christensen and Sanders, 1987, Friman and Leibowitz, 1990, Larsson, 1972). Two studies were deemed to have low risk of bias (Haryett et al., 1967, Villa, 1997). Use of blinding was only clearly stated in one study (Villa, 1997), and this was assessed as adequate.

Four of the studies had adequate sequence generation; coin flip (Azrin et al., 1980, Friman and Leibowitz, 1990), sampling without replacement procedure (Christensen and Sanders, 1987), and random sample tables (Larsson, 1972). For the other two studies, sequence generation was unclear (Haryett et al., 1967, Villa, 1997).

Allocation concealment was either unclear in all studies or not used.

There were three studies that provided clear information about incomplete data and dropouts (1990, Haryett et al., 1967, Friman and Leibowitz, Villa, 1997). One study

(Azrin et al., 1980) did not state the number of participant drop outs or reasons. One study (Larsson, 1972) recorded one drop out in the results but no reason was given. The other study (Christensen and Sanders, 1987) implied that there were no drop outs in the control group but there were no figures to confirm this. Only one study (Azrin et al., 1980) was found to have selective reporting, where there was no allowance for incomplete data.

Regarding other potential sources of bias, in one study (Villa, 1997) there was a small sample size (24 participants), and it was unclear as to whether it was free of other bias, as the results were immediately following removal of the intervention, compared with a no treatment control group. The intervention was an orthodontic appliance which had been cemented in situ for three months. There was no mention of how many of the participants had cessation of the habit during this time, and, therefore, if the improvement they recorded in malocclusion would remain stable once the appliance was removed.

Another area of concern was sampling due to the recruitment method employed in some of the studies. Two studies (Azrin et al., 1980, Christensen and Sanders, 1987) recruited by placing an advert in a local newspaper asking parents to apply. This had high bias potential due to having very interested and supportive parents involved. The other recruitment methods were; recruitment through the child's dentist (Friman and Leibowitz, 1990, Haryett et al., 1967), following an incidence study (Larsson, 1972), and following a screening programme (Villa, 1997).

### **3.8.6 Effects of interventions**

Because of the variety of both the interventions and the outcome measures between the studies, it was not possible to combine the data meaningfully. An overview of the interventions is provided, by describing them separately for each study (see 3.8.7). Detailed below are the effects of the interventions relating to the outcomes; the primary outcome of cessation of the habit (Table 3.2), the secondary outcome relating to child and parent/carer measures (Table 3.3) and the secondary outcome related to reduction in malocclusion (Table 3.4).

There is no table showing the time taken for the intervention to be effective as there were no data on this.

**Table 3.2;** Cessation of digit sucking after the intervention.

Study	Inter- vention A	Inter- vention B	Inter- vention C	Inter- vention D	Inter- vention E	Control	Measurement of cessation	Cessation
<b>Azrin et al., 1980</b> (n=30)	Habit reversal					Bitter substance	% of children with cessation of the habit	47% HR group, 10% control
<b>Christens en and Sanders, 1987</b> (n=30)	Habit reversal	Differential Reinforcem ent of other behaviour				Waiting list (no treatment)	Number of children with cessation	2/10 HR group, 1/10 DRO group, 0/10 control
<b>Friman and Leibowitz , 1990</b> (n=34)	Aversive taste treatment and reward system					Waiting list (no treatment)	% time intervals with observed thumb sucking before and after intervention	44% to 4% AT group, 44% to 51% control
<b>Haryett et al., 1967</b> (n=66)	Psychology (A)	Palatal arch (B)	Psych & Palatal arch (C)	Palatal crib (D)	Psych & Palatal crib (E)	No treatment (F)	% of children with cessation	9.1% A, 9.1% B, 27.3% C, 100% D, 100% E, 10% control
<b>Larsson, 1972</b> (n=76)	Positive reinforceme nt	Negative reinforceme nt	Palatal crib			No treatment	% of children with cessation	26% PR, 53%, 42% palatal crib, 5% control



**Table 3.3;** Child/parent/carer centred outcomes.

<b>Study</b>	<b>Outcome</b>	<b>Intervention A</b>	<b>Intervention B</b>	<b>Intervention C</b>	<b>Intervention D</b>	<b>Intervention E</b>	<b>Control</b>
Christensen and Sanders, 1987 (n=30)	% of children with oppositional behaviour before intervention and at follow up	Habit reversal	Differential reinforcement of other behaviour				Waiting list (no treatment)
		3.1% to 0.2%	2.5% to 0.6%				2.7% to 2.7%
Haryett et al., 1967 (n=66)		Psychology	Palatal arch	Palatal arch & psychology	Palatal crib	Palatal crib & psychology	No treatment
	No. upset by treatment	1	0	2	6	2	0
	No reported eating difficulty	0	0	0	3	6	0
	No. with development of mannerisms	6	1	1	4	0	1

**Table 3.4;** Reduction in malocclusion following intervention.

<b>Outcomes from Villa (1997) study</b>	<b>Control</b>	<b>Palatal Crib</b>	<b>Statistically significant</b>
Reduction in AOB (mm)	-0.4 s.d. 0.8	3.7 s.d. 1.9	Yes, $p<0.001$
Change in mandibular arch length (mm)	0.03 s.d. 0.19	-1.2 s.d. 0.8	Yes, $p<0.01$
Change in maxillary arch length (mm)	0.01 s.d. 0.33	-1.4 s.d. 1.4	Yes, $p<0.05$
Net change in overjet (mm)	0.02	-0.2	

### **3.8.7 Overview of the effectiveness of the interventions**

#### **1. Habit reversal versus aversive tasting substance**

(Azrin et al., 1980)

Forty seven percent of participants in the habit reversal group, and 10% in the aversive tasting substance group had cessation of the habit after three months from the initiation of the intervention. Patient numbers could not be calculated for this paper as the percentages given don't relate to whole numbers of patients (e.g. 47% of 18 patients treated = 8.46 patients). This is discussed further under Quality of the Evidence.

#### **2. Habit reversal versus differential reinforcement of other behaviour (DRO) versus control group**

(Christensen and Sanders, 1987)

Habit cessation was 30% in the HR group (3/10) at the end of the intervention and 20% at follow up (2/10) and 20% (2/10) and 10% (1/10) respectively in the DRO group. It was not reported in the control group.

The proportion of time spent sucking at baseline compared to follow up was 67% to 20% in the HR group, 68% to 29% in the DRO group, and 70% to 67% in the control group.

Changes observed in oppositional behaviour from baseline to follow up was 3.15% to 0.2% (HR), 2.5% to 0.6% (DRO) and 2.7% to 2.7% (control).

Regarding parents' attitude there were no statistically significant differences in recommending the treatments to others, Table 3.5. However, the numbers of patients treated with each intervention was only ten.

**Table 3.5;** Parents' attitudes to the intervention.

Intervention	Would definitely recommend	May recommend	Unsure if would recommend
HR	8	2	0
DRO	5	3	2

### **3. Application of an aversive taste and reward system versus control**

(Friman and Leibowitz, 1990)

The percentage intervals with observed thumb sucking pre-test and post-test were 44% and 4% in the intervention group and 44% and 51% in the control group.

The acceptability of prescribed treatment was also recorded using a 7 point Likert type scale, with 1= very acceptable and 7= very unacceptable. The mean rating was 1.3 for parents, 1.5 for Paediatricians and 1.2 for Psychologists.

### **4. Control versus psychological treatment, versus palatal arch, versus palatal arch and psychological treatment, versus palatal crib, versus palatal crib and psychological treatment**

(Haryett et al., 1967)

Cessation was 10% in the control group (1/10), 9.1% in the psychology group (1/11) (RR 0.91, CI 0.07, 12.69,  $p=0.94$ ), 9.1% in the palatal arch group (1/11) (RR 0.91, CI 0.07, 12.69,  $p=0.94$ ), 27.3% in the palatal arch and psychology group (3/11) (RR 2.73, CI 0.34, 22.16,  $p=0.35$ ), 100% in the palatal crib group (11/11) (RR 7.03, CI 1.58, 31.24,  $p=0.01$ ) and 100% in the palatal crib and psychology group (11/11) (RR 7.03, CI 1.58, 31.24,  $p=0.01$ ).

Risk ratios were also calculated for the secondary outcome of upset, control versus psychological treatment (RR 2.75, CI 0.12, 60.70,  $p=0.52$ ), control versus palatal arch (RR not estimable as no one in this group suffered upset), control versus palatal arch and psychology (RR 4.58, CI 0.25, 85.33,  $p=0.31$ ), control

versus palatal crib (RR 11.92, CI 0.76, 187.82,  $p=0.08$ ) and control versus palatal crib and psychology (RR 4.58, CI 0.25, 85.33,  $p=0.31$ ). None were statistically significant.

### **5. Positive reinforcement versus negative reinforcement versus palatal crib therapy versus control**

(Larsson, 1972)

In the positive reinforcement group 26.3% stopped their habit immediately post treatment (5/19)(RR 5.00, CI 0.64, 38.87,  $p=0.12$ ) with 52.6% in the negative reinforcement group (10/19)(RR 10.00, CI 1.42, 70.63,  $p=0.02$ ), 42.1% in the palatal crib group (8/19)(RR 13.09, CI 1.44, 119.34,  $p=0.02$ ) and 0.05% (1/19) in the control group stopping.

At eight months the number of participants who had stopped in each group were 10, 11, 10 and 6 respectively, positive reinforcement (RR 1.67, CI 0.76, 3.66,  $p=0.20$ ), negative reinforcement (RR 1.83, CI 0.85, 3.94,  $p=0.12$ ) and palatal crib (RR 1.76, CI 0.81, 3.84,  $p=0.16$ ).

At 12 months the results were; positive reinforcement 11/19 (RR 5.50, CI 1.4, 21.56,  $p=0.01$ ), negative reinforcement 14/19 (RR 7.00, CI 1.84, 26.68,  $p=0.004$ ) and palatal crib 11/18 (RR 5.81, CI 1.49, 22.66,  $p=0.01$ ), with 2 participants having stopped in the control group.

### **6. Palatal Crib Therapy versus control**

(Villa, 1997)

In the palatal crib group the AOB changed from 5.0mm pre-treatment to 1.3mm post treatment, and in the control group from 4.6mm to 5.0mm.

The change in maxillary arch length was a reduction of 1.4mm in the intervention group, and increase of 0.01mm in the control group. The change in mandibular arch length was a reduction of 1.2mm in the intervention group, and an increase of 0.03mm in the control group. This would appear to give a net change in overjet of -0.2mm (a decrease) in the intervention group, and 0.02mm (an increase) in the control group.

### 3.9 Discussion

Dentists and other oral health care professionals are regularly asked by parents and carers about effective methods for helping children to stop sucking habits. This review aimed to assess the effects of interventions for cessation of non-nutritive sucking habits (NNSHs) in children, and their acceptability to patients, parents and dentists, providing guidance for clinicians faced with this scenario. Given that these habits are so common amongst children in many different countries, it is surprising that few studies were able to be included in this review, and that none of these have been conducted in the past decade and a half. In addition, the trials included digit sucking and no other NNSHs.

The primary objective of the review was to ascertain the effectiveness of different interventions for cessation of NNSH in children. Six trials, with 252 enrolled children, aged between two and a half and eighteen years of age, were included. However, the wide ranging clinical interventions (psychology, application of an aversive tasting substance to digits, and use of intra-oral orthodontic appliances), and the differing timescales they were implemented for and assessed at, together with a lack of standardization of outcomes measures, meant that the findings of the studies could not be combined meaningfully. In addition, the quality of the studies generally was poor methodologically. The paucity of studies and their low quality has meant that this systematic review cannot present a clear overview of the relative effects of different treatments, and consequently, there is a lack of evidence to support clinical decision making for cessation of NNSH. However, descriptive tables have been compiled to give an overview of the evidence, and there were some consistent findings across the studies despite differing methodologies.

Four studies (Haryett et al., 1967, Larsson, 1972, Azrin et al., 1980, Christensen and Sanders, 1987) measured the primary outcome of cessation of NNSH. With the exception of provision of psychology only, or a palatal arch only (Haryett et al., 1967), the intervention groups for all four studies had either a greater number of participants who stopped their thumb sucking habit, or had a reduction in the number of times they sucked their thumb, compared with a no-treatment control group. However, because the studies had a large number of sub-groups of

participants undergoing different interventions, there were low numbers of participants analysed in each group (all less than 20) and although they all showed a successful effect of treatment, it is difficult to be certain about the extent of the findings. Although Haryett et al. found 100% habit cessation with both the palatal crib (11/11 children), and the palatal crib with psychology (11/11 children), this would seem indicative of treatment success, but it is difficult to make this applicable to a larger population. It should also be borne in mind that this outcome was recorded immediately after removal of the appliances (where they had been worn for 10 months). Unfortunately, there was no follow up for these patients, so it was not possible to know whether this habit cessation was maintained long term.

The difficulty with interpreting the findings in such small groups can be seen in Larsson's study. In the control group, the habit cessation rates were one out of nineteen immediately after treatment, six out of nineteen at eight months, and this reduced to only two out of nineteen at 12 months. These are unusual findings as, given time, the majority of children with a NNSH stop their habit and it would appear from this data that there has been re-uptake of the habit after cessation.

There was very little data in the studies about the duration of treatment and long term follow up regarding cessation of habit, and it was not possible to determine the age at which the treatment would be most effective. Furthermore, there may be a period of time when the occlusion is establishing where absence of a NNSH may be more critical than at another stage. For example, it may be that re-uptake of a NNSH might have very little effect in a 12 year old, where the occlusion is more established than in a seven year old. No conclusions could be drawn on the time taken for different interventions to be effective, as they were in place for different lengths of time, and follow up occurred at differing time points.

There was also a lack of precision in measuring outcomes regarding time taken for effective treatments. For example, in the paper by Haryett et al., where the palatal crib was in place for 10 months, and 100% success was achieved with cessation of habit, there was no information on which time point this occurred, or even whether the same result would have been achieved in a shorter timeframe.

Only two studies reported secondary outcome data related to behaviour of child and parent/ carer centred measures. These were ‘oppositional behaviour’ (Christensen and Sanders, 1987), upset during treatment, eating difficulties, and development of mannerisms (Haryett et al., 1967). However, the numbers of patients for which these were reported were small, and the findings again inconsistent. The number of participants who developed these were six out of eleven when psychology alone was provided, four out of eleven with a palatal crib only, and yet this decreased to zero out of eleven when a palatal crib was provided together with psychology. Given the conflicting nature of the data, and the small numbers, it is not possible to draw clear conclusions.

Orthodontic appliances were used in three studies (Haryett et al., 1967, Larsson, 1972, Villa, 1997). However, no information was given on ease of fitting or removing the appliances. All were fixed appliances, although a removable deterrent appliance is sometimes used in the UK for managing persistent thumb sucking habits, particularly if it is a night only occurrence, and the patient is motivated to stop.

Changes in malocclusion following cessation of habit were only recorded in one study (Villa, 1997) where palatal crib use was compared with a control group. Although changes in mandibular and maxillary arch lengths were reported as statistically significant, the authors did not mention the clinical significance of the findings. The actual changes were less than 1.5mm for the palatal crib intervention group, and would generally not be considered clinically important. However, the statistically significant reduction in anterior open bite of 3.7mm in the palatal crib group ( $p < 0.05$ ) is clinically important. There was no statistically significant net change in overjet between the groups. Correction of posterior crossbite was not measured in this study despite being a well-recognised feature in the malocclusion of a child with a thumb sucking habit.

Although it is not possible to draw definitive conclusions from the data presented within these six studies, there were some consistencies within these studies that allow for recommendations to be made. Consistently high rates of cessation were found with use of a palatal crib; Haryett et al. 100% (of children) at ten months, and Larsson 42% at 2 ½ months. Although this is an expensive



treatment option it does have a high success rate. In the case of a digit sucking habit, application of an aversive taste substance may be recommended as a first line of treatment.

### **3.10 Summary of main results**

Summarising the findings from studies included in this review and drawing conclusions is constrained by the wide variation in interventions and study methodologies. The objective of this review was twofold, to assess the effectiveness of different interventions for stopping NNSHs, and to identify acceptability of interventions. Six studies were included, but due to their clinical heterogeneity, it was not possible to combine the data meaningfully and perform any statistical analyses. Despite this, there are some inferences that can be made from the data; a palatal crib in situ for 10 months can be highly effective in stopping a thumb sucking habit in the short term (the long term cessation rate is unknown). In addition, aversive tasting substance application to the digit and psychological interventions involving reward systems (possibly in combination with aversive tastes) are also effective to some extent. Providing psychological therapy or using an aversive tasting substance seems to result in cessation of digit sucking habits, although it is not possible to tell from the data in the studies the optimum time for this to be applied. There is also limited evidence that use of a palatal crib appliance for habit cessation resulted in a reduction in the severity of anterior open bite development (Villa, 1997).

### **3.11 Overall completeness and applicability of evidence**

This review has highlighted that the body of evidence for this subject is weak. There are very few trials which met the inclusion criteria with small numbers of children included, a wide age range, and they are published over a 30 year period. This review identified a wide range of interventions, with differing durations, and interventions which were aimed at children or parents or both. A range of outcomes were found along with different duration of follow up for

participants following the interventions. This has made it difficult to carry out direct comparisons and the conclusions that can be made are weak.

It was interesting to note that there were no studies included in the review which used removable orthodontic appliances to stop NNSHs, a method that is common practice in the UK. Furthermore, it is interesting to note that there were no studies looking at interventions for pacifier habits, but this may be due to the fact that it is easy to withdraw pacifiers, and consequently eliminate the problem.

### **3.12 Quality of the evidence**

This review has included six RCTs, one of which was assessed as being of low risk of bias (Larsson, 1972). The lack of standardised measures and the low quality of these studies may, at least in part, be a result of their age.

There were concerns regarding the recruitment process used in the studies. Two of the studies (Azrin et al., 1980, Christensen and Sanders, 1987) recruited their participants by advertising in newspapers to which the parents of the participants replied. Both these studies relied on parents providing the intervention. In two studies (Haryett et al., 1967, Friman and Leibowitz, 1990) the participants were referred to secondary care centres by either a dentist or paediatric provider. One study identified the participants by sending questionnaires to parents, where the parents graded their child's sucking intensity, and only those with the most severe sucking habits were recruited (Larsson, 1972). The last study recruited the participants by selecting patients with a sucking habit who attended an Orthodontic clinic (Villa, 1997).

There were also some concerns related to the study by Azrin et al. regarding the methodology and results. Nowhere in the text does it state how long parents continued to apply the aversive tasting substance to the participants' digits. In the results, the outcome measure is the percentage of participants who have cessation of the habit three months post intervention. However, both groups are expressed as a percentage which does not equal a whole number.

The study by Friman and Leibowitz is also unclear in the exact amount of aversive taste treatment required to attain cessation, and relied on verbal reports from parents.

### **3.13 Potential biases in the review process**

A sensitive search strategy was used in this review with every effort made to identify all relevant studies. No studies were excluded due to language.

Data collection and analyses were carried out independently with any disagreement resolved by discussion amongst the reviewers.

### **3.14 Conclusions**

There is weak evidence to suggest that fitting a palatal crib as a deterrent appliance, providing psychological therapy, or using an aversive taste treatment will result in reduction or cessation of digit sucking habits. Given that use of aversive tasting substance requires no clinical input, is a non-invasive procedure, is cheap and can be carried out by parents in the home setting, it would seem prudent that this is tried as a first line of treatment although it did not have as high a success rate as use of a palatal crib. As a second line of treatment, a palatal crib appears to be most successful for attaining cessation of the habit in the short term, and can result in reduction of an anterior open bite.

Clinical trials should be conducted on cessation of NNSHs with intervention groups which have a psychological input, or are provided with an orthodontic appliance, or have application of a bitter substance to the digit, all compared with a no treatment control group. These trials should be well designed, and follow the Consolidated Standards of Reporting Trials (CONSORT) statement (Schulz et al., 2010) leading to trials with low levels of bias. The trials should all have a standardised primary outcome, ideally the number of participants with cessation of habit following an intervention, and clear time frames for both intervention and follow up.

## **Chapter 4**

### **A Systematic Review of Correction of Anterior Crossbites in Children**

## 4.1 Introduction

From the literature overview it can be seen that there is a need to consolidate the numerous case reports in the literature surrounding the management of anterior crossbites in children. Presented in this chapter is a systematic review to help identify the most efficient treatment for children with this malocclusion. It was hoped to conduct this review following Cochrane methodology, but an initial search revealed there to be no controlled trials in this area, therefore this was not appropriate. A systematic review including the available studies was, therefore, conducted

## 4.2 Background

Anterior crossbite refers to “an abnormal labiolingual relationship between one or more maxillary and mandibular anterior incisor teeth. Clinically it is expressed as a reverse overjet in which one or more maxillary teeth are positioned lingually to the mandibular incisor teeth when the patient closes his mouth into centric occlusion” (Lee, 1978). It has also been described as being “due to an abnormal axial inclination of one or more maxillary incisors, which may be lingually positioned” (Sharma and Brown, 1968).

The aesthetics of an anterior crossbite are poor but more importantly if the condition is left untreated it may lead to:

- damage to the teeth in crossbite through attrition (de Boever and van den Berghe, 1987, Jirgensone et al., 2008);
- gingival recession and loss of alveolar bone support to the lower incisor;
- temporomandibular dysfunction (TMD), which has been associated with childhood anterior crossbites (Thilander et al., 2002, Barrera-Mora et al., 2012);
- mobility of the lower incisor affected by the crossbite (Jones and O'Neill, 1996); and,
- potential adverse growth influences on the mandible and the anterior portion on the maxilla, (Lee, 1978, Sexton and Croll, 1983, Valentine and Howitt,

1970) involving not just the teeth and alveolar processes, but skeletal structures of the mandible and maxilla (Clifford, 1971).

In addition to preventing the possible sequelae listed above, the additional benefits of early treatment have been reported as:

- preventing adverse growth and re-establishing proper muscle balance before deteriorating effects become well established (Chow, 1979);
- improving maxillary lip posture and facial appearance if corrected in the mixed dentition (Croll and Riesenberger, 1987); and
- providing space for eruption of canines. Lack of space in the arch could be caused by retroclined maxillary incisors frequently found in these cases (Rabie and Gu, 2000).

The prevalence of all types of anterior crossbite varies in the literature from 2% to 12% depending on the age of the children studied, whether or not an edge to edge incisor relationship is included in the data, and depending on the racial group studied. Karaiskos et al. (2005) looked at a group of six year old and nine year old Canadian children and found anterior crossbites in 11% and 12% respectively (including edge to edge relationships). A study looking at 545 Finnish children with a mean age of five years found that an anterior crossbite occurred in 2% of children (Keski-Nisula et al., 2003). In a study in Germany involving 494 children, with a mean age of nine years, 3% of males and 5% of females had a crossbite, with the crossbite particularly affecting lateral incisors (Lux et al., 2009). A UK source reports the incidence of anterior crossbites to be between seven and 10%, depending on the age of the child (O'Brien, 1993). Anterior crossbite is a condition that establishes and presents in the mixed dentition, and once identified the treatment should ideally involve a technique which is simple, non-invasive, involves little chair side time, requires minimal patient co-operation, and gives rapid correction of the cross bite. In the young patient group, compliance can be an issue, but appearance less so. Therefore, the types of intervention need to be different than those used on an adolescent patient, where aesthetics and appearance usually help drive the treatment motivation. Patients with an anterior crossbite will benefit from interceptive

treatment, preventing the need for more complex treatment at a later date to correct this simple anomaly.

For this review anterior crossbites due to a skeletal class III relationship will not be considered, as the purpose is to review interceptive treatment for anterior crossbites in children and not the management of skeletal class III malocclusions. Harrison et al. (2002) are currently undertaking a Cochrane review entitled “Orthodontic treatment for prominent lower front teeth in children.” The authors of this review intend to look at patients with underlying skeletal discrepancies and their outcome measures include the prominence of the lower front teeth and the relationship between upper and lower jaws.

### **4.3 Aim**

The overall aim of the review presented in this chapter, was to provide evidence to support clinical practice in the management of anterior crossbites in general dental practice. The rationale for carrying out this review was to identify which techniques are most effective at early correction of the anterior crossbite in the child patient. This is timely, because a reduction of orthodontic provision in general dental practice has resulted in specialist orthodontists increasingly being required to undertake anterior crossbite correction (Richmond and Karki, 2012).

### **4.4 Materials and Methods**

This systematic review focused on children with one or more incisors in crossbite, without a class III skeletal relationship, receiving any orthodontic technique to correct the crossbite. Types of studies to be included were those where there was comparison with either a control group or comparison of different techniques, and where the outcome was correction of the crossbite and treatment duration. The inclusion criteria were defined as:

- papers written in English;
- children either in the deciduous dentition or the mixed dentition;
- one or more incisor teeth in crossbite;
- no reported underlying Class III skeletal relationship or posterior crossbite;
- and,
- no cleft lip and palate, or other craniofacial abnormalities.

The time taken to correct the crossbite was required to be recorded, excluding re-treatment cases, along with full description of the technique used to correct the crossbite.

A search strategy was developed and performed in the online databases, Scopus, EMBASE, the Cochrane Library, Medline and psychINFO on the 23rd November 2010.

Search strategy:

1. mixed dentition OR child\*
2. reverse overjet OR anterior cross-bite\* OR anterior crossbite\*
3. pseudo class III OR pseudo-class III
4. pseudo class 3 OR pseudo-class 3
5. #1 AND (#2 OR #3 OR #4)

Hand searching the literature was carried out for the following journals:

- Angle Orthodontist, 1931 to 1950;
- European Orthodontic Society, 1962 to 1964 (now the *European Journal of Orthodontics*);
- British Society for the study of Orthodontics, 1965 to 1970 (subsequently the British Journal of Orthodontics and now the Journal of Orthodontics).

The levels of quality of evidence were to be assessed using the GRADE approach, as used by the World Health Organization, the American College of Physicians, the National Institute for Health and Clinical Excellence in the UK, and others (O'Brien et al., 2007). With regard to systematic reviews the GRADE approach defines the quality of a body of evidence as the extent to which one can be confident that an estimate of effect or association is close to the quantity of specific interest (Josefsson et al., 2007, Balshem et al., 2011).

A separate assessment of risk of bias was planned based on the Cochrane tool for assessing risk of bias, which is a domain based evaluation (Higgins and Green, 2009). This considers sequence generation, allocation concealment, blinding of participants, personnel and outcome assessors, incomplete outcome data, selective outcome reporting, and other sources of bias for each study. Each aspect of study design involves answering specific questions where an answer “yes” indicates a low risk of bias and a “no” answer indicates a high risk of bias.



## 4.5 Results

The electronic search identified 475 articles, and hand searching the literature identified a further 6 articles. The titles and abstracts were studied for their eligibility for inclusion in the review, along with checking their references for further studies. This resulted in a total of 499 publications for consideration. Using the inclusion criteria the titles, and where necessary abstracts, were checked for suitability and this reduced the number of publications eligible for inclusion to 131. The complete text of these 131 accepted articles was obtained, and a further decision based on the inclusion criteria was made thereafter. All references from accepted papers were cross checked, and where necessary further articles obtained and checked for suitability for inclusion. Only papers written in English were accepted for the review, eliminating 12 publications, none of which were a controlled trial. This process resulted in 46 papers included in the review (Figure 4.1). These papers were studied by both reviewers independently, and their categorisation of type of study determined (Table 4.1). There were two papers where there was disagreement between the reviewers regarding the type of study reported in the paper, but after discussion this was resolved.

**Table 4.1;** Inter-rater agreement for papers included in the review.

	Cohorts	Case series	Case reports	Total
Cohorts	3	0	0	3
Case series	0	2	1	3
Case reports	0	1	39	40
Total	3	3	40	46

Number of observed agreements: 44 ( 95.65% of the observations)

Number of agreements expected by chance: 35.2 ( 76.47% of the observations)

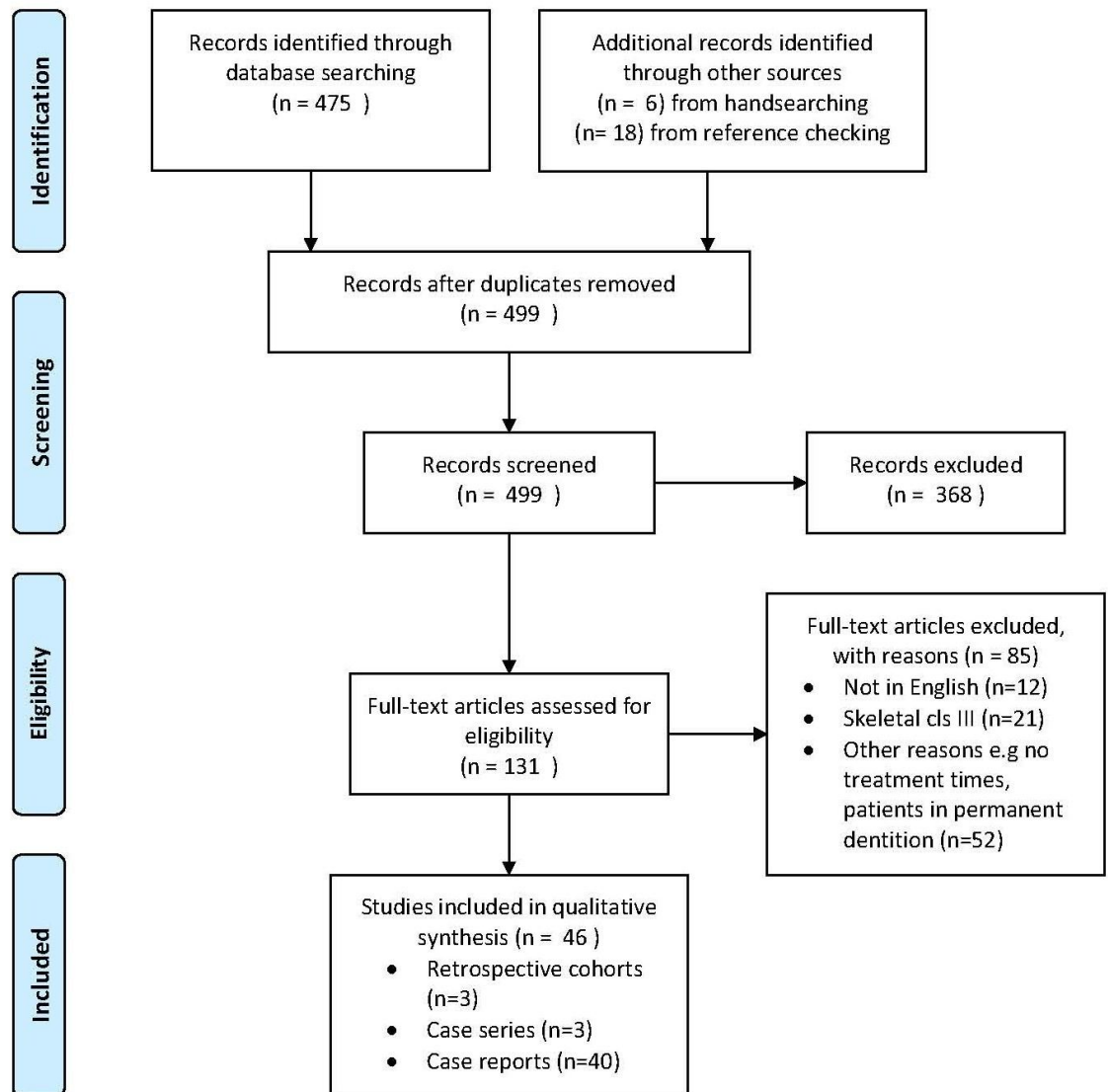
Kappa= 0.815

SE of kappa = 0.127

95% confidence interval: From 0.566 to 1.064

The strength of agreement was considered to be 'very good'.

**Figure 4.1;** Flow chart outlining the search methodology, and numbers of articles included/excluded at each stage.



Of the 46 papers included in the review there were 3 retrospective cohorts, 3 case series, and 40 case reports. Definition of a case series, compared with a case report, was where the same treatment was provided to five or more patients. All papers were either of low or very low quality rating, according to the GRADE rating system (Balshem et al., 2011). The levels of quality and association with

methodology in the GRADE approach are shown in Table 4.2 (Higgins and Green, 2009).

According to the GRADE system, low quality evidence is where further research is likely to have an important impact on our confidence in the estimate of effect, and may change the estimate. With very low quality evidence, any estimate of effect is very uncertain (Oxman, 2004), therefore no formal data synthesis or meta-analysis was undertaken. No risk of bias was carried out as there were no controlled trials and therefore no sequence generation, allocation concealment, blinding of participants or clinicians.

**Table 4.2;** Levels of quality of evidence using the GRADE approach.

<i>Underlying methodology</i>	<i>Quality rating</i>
Randomised trials; or double-upgraded observational studies	High
Downgraded randomised trials; or upgraded observational studies	Moderate
Double-downgraded randomised trials; or observational studies	Low
Triple-downgraded randomised trials; or downgraded observational studies; or case series/case reports	Very Low

Downgrading of the quality of evidence occurs when any of the following factors are present;

- Limitations in the design and implementation of available studies, suggesting high likelihood of bias;
- Indirectness of evidence;
- Unexplained heterogeneity or inconsistency of results;
- Imprecision of results; and
- High probability of publication bias.

Where two factors are present double-down grading occurs, and when three are present triple-down grading occurs.

#### **4.5.1 Types of studies**

##### *1. Retrospective Cohort Studies*

The first cohort (Rabie and Gu, 1999) looked at 21 children in southern China, with a mean age of 9 ½ years. They had at least two incisors in crossbite and had a pseudo class III relationship. All were provided with a “2 x 4” appliance, with an initial levelling wire in 0.016” NiTi for one to two months, followed by advancing loops in 0.016” SS wire for three months. The appliance comprised of bands on the upper first permanent molars (although bonded buccal tubes can be used) and brackets on the four upper incisors. Two patients also had a lower “2 x 4” appliance with closing loops in the lower arch to retrocline the lower incisors. The anterior crossbite was eliminated after a total of five months, and the incisors were aligned. The paper additionally discussed two of the cases in more detail, with their treatment times slightly longer, seven and eight months, as detailed torque to the upper incisors was also provided.

The second study (Gu et al., 2000) had a group of 17 patients with pseudo class III malocclusions, who were treated with simple fixed appliances, a “2x4 appliance.” The mean age was 9.7 years and the average treatment time was 8.4 months. The prescription was the same as in the study above, with one to two months of aligning, and two to three months of incisor proclination to achieve correction of the anterior crossbite. The subsequent months of treatment were to achieve detailed torque. Of the three papers which were retrospective cohorts, the third was a report of a five year follow up of the cohort reported above (Gu et al., 2000, Hägg et al., 2004).

The third study (Hägg et al., 2004), had a group of 27 young patients, mean age 10.1 years, with a pseudo class III malocclusion. Seventeen patients included were from the study above (Gu et al., 2000). They were treated with a “2 x 4” appliance, followed up five years later, with only two patients having been lost to follow up. The average treatment time was 0.63 years, and at follow up all patients still had a positive overjet.

##### *2. Case Series*

These were in the form of small retrospective, descriptive, non-consecutive case series reports. One article looked at a passive method to correct anterior crossbite (Estreia et al., 1991). The authors looked at 15 children, aged six to

eight years of age, with only one central incisor in crossbite. The interceptive technique involved bonding composite material to the opposing lower incisor, to create an inclined bite plane with an inclination of approximately 45 degrees and 3 to 4mm high. This resulted in posterior disclusion with only two teeth in contact, the upper incisor previously in crossbite, and the lower incisor on which the composite was bonded. All patients were reviewed after one week and at the review all had the upper incisor in a normal position along with no posterior open bite. The composite was removed at this visit. A further review was carried out at three months where no relapse was observed.

The other case series was similar in method, using the same mode of treatment, a composite inclined bite plane bonded on to the corresponding lower incisor. The patients selected had only one tooth in crossbite, although they didn't specify whether this included lateral incisors or not (Sari et al., 2001). They treated 35 patients, seven to eleven years of age, and reviewed them after one week of having the inclined bite plane. Thirty-three of the 35 patients had correction of the crossbite after one week, leading to removal of the bite plane, and all were still in positive overjet at a three month review. The two cases which had failed to be corrected in this time had a deep bite and a rotated incisor respectively.

The authors recommend this treatment in patients with one incisor in crossbite where the overbite is not more than 1/3 the crown length, the tooth is not rotated, there is sufficient mesio distal space for the tooth, and the problem is solely dental in origin.

### *3. Case reports*

In view of the large amount of data obtained from the case reports, in terms of appliance design, teeth in crossbite, age of patient and time for treatment to be successful, it was decided to arrange the data by appliance design (Table 4.3).

The treatment time (Tx time) was the time to treat the crossbite only and not the total time the patient had orthodontic treatment.

**Table 4.3;** Case reports, types of treatment provided, and treatment time.

<b>Author</b>	<b>Teeth Affected</b>	<b>Removable Appliances</b>	<b>Tx time</b>	<b>Age of pt</b>
Valentine and Howitt, 1970	22	Hawley with “Erel-Micro screw” & posterior bite plane	7d	8y7m
Mamandras and Magli, 1984	11,21 (63)	URA, posterior Bite Plane & Z springs	5m	9y
Ghafari, 1985	11,21	Lip bumper	16w	8y
Jones and O'Neill, 1996	11,21	URA with Z springs	1m	7y
Al-Sehaibany and White, 1998	11,21	URA (ultrablock)	6m	8y
Giancotti et al., 2004	11	2 Essix appliances	15w	8y
Jirgensone et al., 2008	52,11,21	“Bruckl appliance” (Removable inclined plane)	2.5m	8y
	12,11,21		1.5m	11y
	11,21		2m	10y
Seehra et al., 2009	11	URA with Z spring	4m	10y
		<b>Functional Appliances</b>		
Graber, 1972	11,21	Cls III activator & with Upper & Lower expansion plates	15m	8.5y
Giancotti et al., 2003	53,11,21,22,63	Balter’s Bionator III	9w	8y10m
	11,21,22,63	As above	7m	9y
	11,21	As above	12w6d	9y
Kapur et al., 2008	53-64	Reverse twin block	2m	8y

		<b>Cemented Appliances</b>		
Tobias and Album, 1977	52,51,61,62	Lower Inclined Bite Plane cemented (LIBP)	3w	1y8m
Sexton and Croll, 1983	51,61	Reversed Stainless Steel Crowns	3w	4y
	62,63	As above on 62 only	3w	4y
Croll, 1984	52,51	Stainless Steel Crowns (SSC)	4w	24m
	52	SSC (2, one on top of other)	3w	43m
	52,51,61	LIBP	31d	35m
Croll and Riesenberger, 1987	52,51,61	Cemented LIBP	11w	15m
	51,61	As above	8w	18m
	62 (&63)	As above	6w	4yr
	52,51,61	SSC 51,61	7w	26m
Croll and Riesenberger, 1988	62	SCC reversed	3w	43m
	52,51,61,62	SCCs & LIBP	17w	30m
	52,51,61	SSC to 51 & LIBP	16w	19m
	62 (& 63)	LIBP (SCC to 63)	8w	3years
Campbell, 1991	52,51,61,62	All had	1m	1.5y
	21	SSCs	1w	7y
	21,22		3m	11y
Croll, 1996	11	SSC	3w	7y

	11	Composite crown	3w	8y
	11,21	Composite crown	4w	9y
Olsen, 1996	21	Upper Bite Plane	6w	9y
Croll and Lieberman, 1999	21	Bonded compomer slope to upper incisor free hand	5w	8y
Tse, 1999	21	Upper Inclined Bite Plane	3w	7y
Nouri and Kennedy, 2001	52,51,61	Fixed Lower Bite Plane (LBP)	2m	3y2m
Croll and Helpin, 2002	11	Bonded compomer bite plane to upper incisor using crown form	“about” 10d	8y
Ayers et al., 2003	11,21	LIBP (cemented)	4w	8y
Tzatzakis and Gidarakou, 2007	52,51,61,62	Glass Ionomer Cement (GIC) to 75,85	2m	7y
	11,21	GIC to 36,46	3m	10y
	21	GIC to 36,46	2m	7y
Bayrak and Tunc, 2008	21	Bonded composite slope to lower incisors	1wk	8y
	11,21		2wk	9y
	11		1wk	7y
		<b>Fixed Appliances</b>		
Asher et al., 1986	12	Sectional Fixed Appliance (FA)	6w	8y
Grimm 3rd, 1991	55-62	Modified Quad Helix + recurved anterior extensions	8w	3.5y
Vadiakas and Viazis, 1992	52,51,61,62	Fixed “W” arch with extended arms to the incisors	4m	3y



Tse, 1997	22	Upper & Lower FA with upper looped archwire	1.5m	11y
Gu et al., 2000	12,11,21	2x4 appliance	5m	10y10m
Bowman, 2008	11,21	All had	3m	9y
	11,21	Fixed appliance, 2x4, with	5m	11y
	12,11,21	“quick fix” device	2m	9y
	12,11,21		7m	11y
		<b>Combination techniques</b>		
Olsen, 1996	22,21,11,12	Sectional FA (4 brackets) & LBP	2m	10y
Clark, 1980	12,11,21,22	URA, lower sectional fixed & Cls 3 elastics	7m	10y3m
Al-Sehaibany and White, 1996	52,51,61,62	2x4 appliance and bonded acrylic to deciduous molars	6m	6y
Skeggs and Sandler, 2002	21	Sectional FA & GIC placed on posterior teeth	10d	8y
Seehra et al., 2009	21	2x4 appliance, GIC to 36&46	3m	10y
		<b>Other techniques</b>		
Chow, 1979	52	Removal occlusal interferences	n/a	6y
Reynolds, 1978	11,21	U & L brackets & elastics	2m	8y
	(21,22		2m	No ages
	11,21		3m	recorded)
McEvoy, 1983	11	Extraction of retained 51 & surgical repositioning of 11	n/a	8y
Gorback, 2001	11,21	Direct bonded buttons & cross elastics	3w	9y

#### **4.5.2 Types of appliances**

##### *1. Removable Appliances*

The first group of case reports to be considered involved providing the patient with a removable appliance. It can be seen from the data that there is a large variation in treatment time, perhaps linked to patient compliance, and with upper removable appliances with active components, the need to reactivate the component. The treatment time ranged from seven days to six months in an age range of eight to 11 years. Two case reports with similar treatment mechanics, a URA with Z springs and posterior bite plane (Mamandras and Magli, 1984), and a URA with Z springs (no posterior bite plane) (Jones and O'Neill, 1996), both to correct a crossbite of 11 and 21, have a very large variation in treatment time, five months versus one month.

##### *2. Functional Appliances*

There are three papers which involve the use of functional appliances. Unfortunately, little can be drawn from these as they are all of different design; two are used in the mixed dentition, and one in the deciduous dentition. The treatment times ranged from nine weeks to 15 months. One case report describes the use of the Bionator III (Giancotti et al., 2003), which is a derivative of the Activator. The reverse Bionator, or Bionator III, is a modified version of the traditional Bionator and can be worn day and night. The lingual wire is in a different position controlling the position of the tongue up to the upper first molar. The labial arch is placed in the middle of the lower teeth, and the acrylic should be made as small as possible in order to occupy minimal space.

##### *3. Cemented appliances*

These are reports of treatment in which the patients were managed with materials bonded to either upper or lower teeth. Some authors used a stainless steel crown, often rotated 180° with the palatal surface facing labially, and temporarily cemented on (Sexton and Croll, 1983, Croll, 1984, Campbell, 1991). Other techniques involved bonding composite, compomer or acrylic to either upper or lower incisors thus creating an inclined bite plane (Tobias and Album, 1977, Croll and Lieberman, 1999, Croll and Helpin, 2002, Bayrak and Tunc, 2008). Another technique was the simple application of glass ionomer cement to the lower molar teeth to free the occlusion (Tzatzakis and Gidarakou, 2007). The

range in treatment time was less extensive, ten days to three months, with an age range of seven to 10 years. These results correspond with the results from the two case series (Estreia et al., 1991, Sari et al., 2001), in which nearly all patients had their anterior crossbite corrected in a week, 15 out of 15 and 33 out of 35 in patients aged six to eight years and seven to 11 years of age respectively.

#### *4. Fixed appliances*

These case reports generally match the results presented in the cohort studies (Rabie and Gu, 1999, Gu et al., 2000, Hägg et al., 2004), with some of the case reports reporting much shorter treatment times of six weeks, eight weeks, and one and a half months (Asher et al., 1986, Grimm 3rd, 1991, Tse, 1997).

#### *5. Combination techniques*

Three papers combine an upper sectional fixed appliance with a component on the lower teeth, either to prop open the occlusion, or in the form of a bite plane. This seems to accelerate treatment time compared with fixed appliances alone, to as little as ten days compared with the most successful case with fixed appliances only reported as six weeks (Asher et al., 1986, Skeggs and Sandler, 2002).

#### *6. Other techniques*

Other treatment systems have also been identified, with the application of brackets/buttons to teeth, combined with use of elastics, being the least invasive technique and having a favourable treatment time. This, however, relies heavily on patient compliance. Removal of occlusal interferences, by using a high speed hand piece, gave instant correction of the crossbite (Chow, 1979), but again required a high level of co-operation from the child patient, and is not a possible correction technique in all cases of anterior crossbite. One article went to the extreme of surgically repositioning an upper central incisor (McEvoy, 1983). This group of “other techniques” was small, with only four case reports found.

## **4.6 Discussion**

This review identified over 400 articles in the search, but only 46 were eligible for inclusion, and these were all of poor quality, therefore no definitive conclusions can be drawn. Despite this, the review has identified the best available evidence for this commonly presenting condition, and consideration should be given to the findings.

From this review, it appears that treatment involving modification to the upper or lower incisors edges, either in the form of a bite plane or application of a temporary crown, gives correction of a single tooth anterior crossbite in a few weeks. The levels of evidence are low and very low concerning this subject, according to the GRADE system. Cemented appliances had a tendency to work within three to four weeks (Tobias and Album, 1977, Sexton and Croll, 1983, Croll, 1984, Croll, 1996, Tse, 1999, Ayers et al., 2003) and fixed appliances correcting the crossbite within six weeks to three months (Grimm 3rd, 1991, Tse, 1997, Asher et al., Bowman, 2008,).

The literature would seem to support treatment as early as possible with respect to limiting root resorption, and also providing treatment of a short duration. Reitan (1974), when studying apical root resorption, suggested that there was a protective mechanism of pre-cementum and pre-dentine located at young apices, and this may be an influencing factor regarding the prevention of root resorption. A recent piece of work by Jiang et al. (2010), found that age is an influencing factor regarding root resorption. They also found treatment duration had a statistically significant correlation with post treatment root resorption, and increased treatment time leading to more severe root resorption.

The case reports do not mention the risks of treatment or mention any radiographs taken to assess root resorption. However, it may be difficult to justify a radiograph to “check” for root resorption, particularly for the patients who were treated with a cemented appliance for only a couple of weeks. It is unlikely to change the management of the patient after the crossbite has been corrected. Ideally, to assess root resorption from tipping forces requires 3D imaging, to visualise the areas of maximum compression and tension, the root apex palatally, and the cervical root buccally, areas not seen on plain films. Finally, it is recognised that there is no control over morphology of roots and rate of metabolism, both of which can have a negative effect on root resorption despite providing optimum treatment.

There are many problems with the evidence provided by case reports. One of these being clinicians presenting only their successful cases. Also, there are multiple variables when comparing these articles such as clinicians will have different levels of success with different techniques due to their own skill set.

Some children will be more co-operative than others, either in the dental chair when having an appliance fitted, or with regard to wearing their removable appliances. Dental factors, such as the degree of displacement of the teeth in crossbite, presence of rotations, and the extent of overbite will also affect success of treatment. However, it is important to remember the role of case reports and case series, providing many new ideas, as a first step to allowing other higher levels of evidence to be obtained and having “a high sensitivity for detecting novelty and remain one of the cornerstones of medical progress” (Vandenbroucke, 2001).

With regard to which teeth were in crossbite, or how many teeth were in crossbite, and length of treatment, nothing could be deduced. It was not possible to carry out a formal assessment of risk of bias, as all studies included in this review were retrospective. The studies all had multiple biases, with one or more of: no sequence generation; no allocation of concealment; no control groups; and selective outcome reporting (it is unlikely that anyone submitting a case report or series for publication will include unsuccessful cases).

It is important to articulate the available evidence and its low quality, given that this is a clinical problem which orthodontists and GDPs deal with regularly. It is important to draw attention to the findings, or lack of findings, uncovered by this review. Currently most teaching provided in UK dental schools, and reported in textbooks, at both undergraduate and postgraduate level, advocates the use of URAs to correct anterior crossbites in the mixed dentition. This review, however, shows that there is lack of high quality evidence to support this technique, and that there are a wide variety of treatment modalities in use. In fact, this review suggests that, albeit at the same level of low evidence, other techniques could have greater effectiveness and efficiency.

#### **4.7 Self-reflection**

Prior to carrying out this review I would normally have used removable appliances to correct anterior crossbites, but having carried out this review I have changed my clinical practice to routinely include other treatment options, such as using temporary composite additions to lower incisors and using “2 x 4” fixed appliances with promising initial results, Figures 4.2 to 4.5. I have also been

actively encouraging colleagues to test these other treatment methods, and feedback their experiences. We are monitoring our outcomes, and will use the information we gain to add to the available evidence base, likely in the form of a case series.

Whilst realising that the evidence found in this review does not strongly support one treatment modality over another, in our recent practise we have found some of the techniques more acceptable to patients. For example, a bonded inclined lower bite plane has been easier to provide in some children, compared to taking an upper impression and obtaining compliance with a removable appliance.

There is clearly a need for high level studies before any definitive recommendations can be made, for example a randomised controlled trial comparing two or more of these interventions.



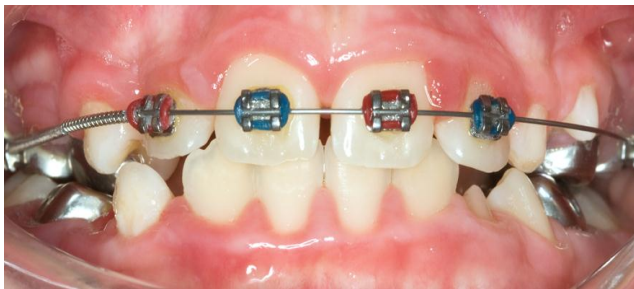
**Figure 4.2;** An 8 year old male with crossbite of UR1, and potential crossbite of UR2, which is partially erupted. There is severe space shortage in the upper right quadrant.



**Figure 4.3;** Composite inclined bite-plane bonded to LR1.



**Figure 4.4;** Correction of crossbite UR1 and further eruption of UR2, showing UR2 to be palatally displaced and therefore requiring bodily movement.



**Figure 4.5;** A “2 x 4” appliance in situ, having corrected UR2 crossbite, and push-coil in the upper right quadrant to create space for UR3.

## 4.8 Conclusions

- More than twelve methods for correcting anterior crossbites are reported in the literature.
- The best level of evidence currently available is that of retrospective cohort studies, which advocate the use of fixed appliances.
- There is a need for high quality clinical trials in this area to identify the most effective intervention for anterior crossbites.

## **Chapter 5**

**A preliminary exploration into General Dental  
Practitioners' beliefs and attitudes regarding  
interceptive orthodontics**



## 5.1 Introduction

The previous chapters have focused on the evidence supporting the management of different aspects of malocclusions presenting in children in the mixed dentition. The importance of the role of the GDP in the diagnosis and management of these conditions has been mentioned briefly, along with the perceived view that there are often missed opportunities in providing interceptive orthodontic (IO) treatment. As an initial step in the process of changing the current behaviour of GDPs, it was felt necessary to investigate the current views and knowledge held by dentists surrounding IO, by performing semi-structured interviews. This chapter describes the interviews and identifies some common themes amongst the GDPs.

## 5.2 Literature Review

### 5.2.1 Background

“The goal of qualitative research is the development of concepts which helps us to understand social phenomena in natural settings, giving due emphasis to the meanings, experiences, and views of all the participants” (Pope and Mays, 1995). Interviewing is a popular qualitative research tool used in dentistry to gain information from patients as well as dentists, particularly about experiences and perceptions. Other forms of qualitative research involve focus groups, or the collection of field notes. Recent topics involving patient interviewing have included awareness of oral cancer (Hertrampf et al., 2012), oral health counselling of parents of children with extensive dental caries (Cashmore et al., 2011), and assessment of motivation and psychological characteristics of adult orthodontic patients (Pabari et al., 2011). Recent topics involving general dentists have included remuneration (Harris and Sun, 2011), tobacco smoking cessation (Ebn Ahmady et al., 2011), and what motivates dentists to work in prisons (Smith et al., 2011).

The terminology in the literature can be confusing, as often the terms questionnaire and survey are used synonymously, with some studies carrying out a questionnaire survey by telephone interview (Al-Dlaigan et al., 2011). The Oxford dictionary definition of interview is:

- a meeting of people face to face, especially for consultation;

- a conversation between a journalist or radio or television presenter, and a person of public interest, used as the basis of a broadcast or publication;
- an oral examination of an applicant for a job, college place, etc; and,
- a session of formal questioning of a person by the police  
(<http://oxforddictionaries.com/definition/interview>).

The definition of a questionnaire is “a set of printed or written questions with a choice of answers, devised for the purposes of a survey or statistical study”  
(<http://oxforddictionaries.com/definition/questionnaire>).

The definition of survey is dependent on whether it is being used as a verb or a noun. If it is a verb the following definitions are relevant;

- look closely at or examine (someone or something);
- investigate the opinions or experience of (a group of people) by asking them questions; and,
- investigate (behaviour or opinions) by questioning a group of people.

If it is being used as a noun then the following definitions are applicable;

- a general view, examination, or description of someone or something; or
- an investigation of the opinions or experience of a group of people, based on a series of questions (<http://oxforddictionaries.com/definition/survey>).

The term “focus group” is often referred to in the literature in combination with interviews. The definition of a “focus group” is “a group of people assembled to participate in a discussion about a product before it is launched, or to provide feedback on a political campaign, television series, etc.”

(<http://oxforddictionaries.com/definition/english/focus%2Bgroup?q=focus+group>)

Therefore, for the purposes of this research, interview will refer to a consultation with a person, whether face to face or over the telephone, and questionnaire will refer to written questions and the term survey will be avoided.

### **5.2.2 Methodology regarding interviews**

Gill et al. (2008) examined the methods of interviews and focus groups, how they work and what they can offer to dental research. They identified three types of interviews: structured, semi-structured and unstructured. The structured interview has a set of predetermined questions, and allows for no or little variation or follow up questions to any answers. They are quick and easy to

perform, but allow for limited participant response. The opposite is true with unstructured interviews, which do not reflect any fixed opinion, and are carried out with little or no limit for responses. Semi-structured interviews are the design most commonly used in healthcare, giving participants some guidance on what to talk about, and are accommodating of participants who wish to expand on any subject. Gill et al. (2008) state that the purpose of research interviews is “to explore the views, experiences, beliefs/or motivations of individuals on specific matters.” They are most fitting when little is known about the research topic, or where beliefs are required from each participant. Gill et al. stress the importance of designing an interview that asks questions which will result in the most information being given from the participants about the research topic, starting with easier questions, and progressing to more challenging ones. The research group recommend piloting the interview to ensure its clarity and capability of answering the research question, allowing for any alterations to be made as necessary. Interviews should take place in interruption free settings and the interviewer should make themselves accustomed with the content, focus on listening, and appear neutral although encouraging. It is recommended that all interviews are taped and transcribed as soon as possible.

Interviews can also be divided into key informant interviews, and intercept interviews, depending on the people being interviewed. With key informant interviews, the interviewee is chosen because of their professional training, affiliation with particular organisations etc, and therefore can provide important information surrounding the acceptability of an intervention to the target population. In intercept interviews, the interviewee is used to assess the reaction of the target population to a potential intervention, often conducted at the point when they are likely to be exposed to an intervention, assessing acceptability (Ayala and Elder, 2011).

### **5.2.3 Methods relating to analysing the data**

There have been many studies which report interviewing of dentists or undergraduate dental students and thematic analysis of the data (Bryant et al., 1995, Boyd, 2002, Temple-Smith et al., 2006, Cane and Walker, 2007, Chaves and De Miranda, 2008, Jenkinson et al., 2008, Rogér et al., 2008, Brocklehurst et

al., 2010, Shepherd et al., 2010, Song et al., 2010, Costa and de Araújo, 2011, Hopper et al., 2011).

Consulting the literature there appear to be three theme based approaches to analysis: Phenomenology (Glaser and Strauss, 1967, Giorgi, 1975, Malterud, 1993, Giorgi, 2010), Grounded Theory (Charmaz, 1990, Corbin and Strauss, 1990, , Charmaz, 2006), and Applied Thematic Analysis (Huberman and Miles, 1983, Benner, 1985, Taylor and Doody, 1985, Boyatzis, 1998).

Phenomenology focuses on subjective human experiences, and allows exploration of the data more deeply, extrapolating beyond the text. However, it is important that the data are not interpreted beyond what is there. It has been thought of as a four stage analysis procedure; getting a total impression, identifying meaningful statements, abstracting the contents of individual statements, and summarising their importance.

Grounded theory uses a systematic comparative technique to find themes and create codes, and can be used to study subjects other than human experience. It is, however, time consuming, as the data needs to be coded for its key points, the concepts (collections of similar codes) are defined, with groups of similar concepts used to generate a theory, the theory being a collection of explanations that make the theory strong.

Applied thematic analysis identifies key themes in the text and transforms these into codes. Care has to be taken so that some data are not omitted. It comprises elements of phenomenology, grounded theory, positivism (interpretations should be derived directly from data observed in a systematic and transparent manner) and interpretivism (the opposite of positivism, where the deeper meaning of communication is investigated) (Guest et al., 2012).

Burnard et al have produced advice on how to analyse and present qualitative data after it has been collected (Burnard, 1991, Burnard, 1994, Burnard, 2004, Burnard et al., 2008). They suggest using the method of thematic content analysis, involving analysing transcripts, recognising themes within the data, and grouping together examples of the themes from the scripts. Data can be analysed and managed using computer packages, or by hand, but either way open coding takes place. This is where a word or short phrase sums up what was said in the text. Following this, all the words/phrases are collected and examined for

repetition, and a list of topics is constructed. The next stage is to look for parallels within the topics. Grouping them together to achieve a list with fewer themes ensues, and a colour or number is assigned to each theme. The transcripts are then marked with the colour/number and the sections of text are cut/pasted under each of the theme headings. In order to verify the process of analysis, it is recommended that more than one researcher independently reviews and explores the transcripts for themes. This also allows for additional insight and identification of themes. As there is no definitive answer regarding validity in this type of research Burnard et al. (2008) recommend the search for, and identification of, unexpected statements and these should be reported.

Mays and Pope have written many articles over the past years investigating analysis, and assessing qualitative research in health care (Mays and Pope, 1995a, Mays and Pope, 1995b, Pope and Mays, 1995, Mays and Pope, 2000, Pope et al., 2000, Pope and Mays, 2009), and have identified five stages of data analysis in the framework approach, summarising them as follows:

1. familiarisation;
2. identifying a thematic framework;
3. indexing;
4. charting; and
5. mapping and interpretation.

#### **5.2.4 Interviews as an aid to developing a questionnaire**

McNair et al. (2006, 2009) are another group of researchers who have used interviews to help formulate a questionnaire. Their first study used a focus group meeting and telephone interviews to help develop a questionnaire which examined patients' perceptions of NHS orthodontic treatment. The transcripts from the meeting and interviews were analysed for issues of importance to patients, regarding the NHS orthodontic treatment which had been delivered to them. These scripts were separated into "units of speech", a continuous period of speech by one individual. Thematic analysis then took place individually by the researchers, and was repeated again having constructed a set of common themes. Three main themes were identified, reasons for undergoing treatment, experiences of wearing braces and benefits of treatment. Subthemes for each theme were also detected. Limitations or potential bias in the study was

associated with the timing of the focus groups. This occurred immediately after debond, when the patient was most likely to be satisfied with the outcome of treatment. Strengths included the facilitator of the focus group was someone not involved with patient treatment, and analysis of the transcripts was undertaken by two examiners, one non-clinical.

Shepherd et al. (2010) have also used information obtained from semi structured interviews to facilitate the design of a paper based questionnaire. In this study, the interviews were performed on a convenience sample of 12 GDPs, identifying their views concerning their role in providing alcohol related health advice. A basic thematic content analysis was carried out on the transcripts. This helped the authors to create an informed postal questionnaire to further understand GDPs views on alcohol, motivation, and attitudes towards providing alcohol advice in practice (Shepherd et al., 2011). The results of this questionnaire have shown that attitude, control beliefs, subjective norm, and self-efficacy significantly predicted intention to provide alcohol related advice (ARA). It was also shown that the GDPs alcohol-related knowledge, or personal alcohol behaviour, did not predict intention to provide ARA. The authors intend to develop and test an intervention to encourage GDPs to provide ARA.

### **5.2.5 Triangulation or mixed methods research**

Methodological triangulation, or mixed methods research, uses more than one method to gather data in an attempt to increase the credibility of the results. In dentistry, qualitative studies have been reported which use both questionnaire and interviews on the same groups of participants (Natto et al., 2005, Dyer and Robinson, 2006, Exley et al., 2009, Keck et al., 2009, Innes et al., 2010, Montaldo et al., 2011, Costa et al., 2012).

For example, Innes et al. (2010) interviewed and gave questionnaires to the same group of general dental practitioners, following their participation in a clinical trial using preformed metal crowns (PMCs) on children. The interviews were analysed qualitatively, to gain insight into the GDPs views on using PMCs. The questionnaires were analysed quantitatively to learn how often they had used PMCs prior to the trial, how likely they were to continue with the technique, and how often they were using this technique on children who were not part of the clinical trial. This research illustrates that depending on the research questions to

be answered, sometimes it is necessary to use different research tools, interviews and questionnaires.

### **5.2.6 Worth of qualitative research**

Mays and Pope (2000) outlined two ways in which qualitative research may be assessed according to validity and relevance. They also propose some questions which should be considered when assessing the quality of a qualitative study:

1. Was the piece of work worth doing at all?
2. Was the research question clear?
3. Was the design of the study appropriate?
4. Was the context or setting clearly described, so that any findings could be related to other setting by the reader?
5. Did the sample include the full range of possible cases or settings so conceptual generalisations could be made?
6. Were the data collection and analysis procedures systematic?
7. Was there sufficient reflexivity (sensitivity to the ways in which the researcher and the research process have shaped the collected data)?

The questions can be used as a simple critical appraisal tool for these types of studies.

The authors of a recent study using semi structured interviews in the general dental practice, were keen to point out the limitations of their work (Song et al., 2010). They interviewed a convenience sample of dentists who volunteered to take part, and no incentive was offered for participating. Recruiting participants can be difficult, and often only those wishing to take part, or interested in the subject respond, expressing their views and leading to bias. The investigators carried out the interviews in the dental surgery after each patient appointment, but due to the busy nature of general practice, there was limitation in the depth of each interview. The authors discuss the dental surgery as the setting for the interview. This location is potentially beneficial, stimulating the dentist to engage in the interview, but may also hinder the interview with the interviewee contributing less to avoid displaying any ignorance in front of the interviewer.

### **5.2.7 GDPs views and knowledge regarding orthodontics**

Before the interviews were constructed, the literature was consulted to begin to understand what beliefs and attitudes dentists might have towards providing

orthodontic treatment. Interestingly, Sheiham et al. (1971) observed over 40 years ago, that a large percentage of GDPs refrained from treating orthodontic patients, and it is still the case today. A study in 1982 endeavoured to identify the factors influencing the amount of orthodontic treatment attempted by recent dental graduates (Brown et al., 1982). The participants had been qualified three to five years. A direct relationship was found between lack of confidence in activating a removable appliance, recognising anchorage loss, and proportion of patients referred to an orthodontist. Whether or not the dentist had attended an orthodontic course since graduating had no influence on the referral pattern, but if they had attended a course they were more likely to treat more patients.

Confidence was found to play a large role in provision of treatment.

Although the remuneration system is different in the United States, orthodontics is still regarded as a post graduate subject. Wolsky and McNamara Jr (1996) examined the orthodontic treatment provided by GDPs in Michigan. The results revealed that 57% of dentists provided some form of limited treatment, such as correction of anterior or posterior crossbite, placement of space maintainers. Nearly 24% provided no orthodontic treatment at all, and 19% provided comprehensive treatment, using fixed appliances.

Galbreath et al. (2006) have also investigated orthodontic treatment provided by general dentists, this time in Kentucky, and tried to identify variables that influence their treatment patterns. Fifty five percent of GDPs had found their pre-doctoral orthodontic training poor. The most commonly reported treatments were space maintainers (57%), correction of anterior crossbites (37%), minor rotations (36%) and habits (33%). Forty three percent stated that they provided no orthodontic treatment. Dentists who received more orthodontic continued education were more likely to provide more treatment, and provide complex treatment. However, those who only had orthodontic education from dental school, were more likely to provide no orthodontic treatment. In these studies by Wolsky et al. (1996) and Galbreath et al. (2006) it would have been interesting to explore the reasons why 24% and 43%, respectively, chose to provide no orthodontic treatment at all, or to identify any differences between the treatment providers and non-providers.



Studies have also been identified which examine GDPs knowledge of orthodontics. The following table (Table 5.1) displays UK based studies, conducted over the last ten years, which have investigated this.

**Table 5.1;** Dentists knowledge relating to orthodontics.

<b>Author &amp; Year</b>	<b>Study type</b>	<b>Participants</b>	<b>Findings</b>	<b>Comments</b>
Foley, 2007	Questionnaire based	Recently qualified working in a dental hospital	Dentists answered questions relating to the mixed dentition and paediatric/orthodontics better than ones relating to MOS conditions	Small sample, n=15
Sutton et al., 2005	Questionnaire based	GDPs	GDPs had low self-perceived knowledge on implants, orthodontics, oral medicine & dental sedation techniques	Self-reported.
Berk et al., 2002	Observational (scored 137 study models with respect to their need for orthodontic treatment)	GDPs, Orthodontists and Paediatric dentists	High level of agreement between the three groups (Kappa range 0.86-0.95) regarding orthodontic treatment need	Does not address issue of timing of treatment.
Rock et al., 2002	MCQ exam paper	Dental students	Average MCQ score was 58% (39-72%). Scored poorer on questions where knowledge had to be applied	Does not relate to clinical practice.

A significant proportion of dentists chose not to provide any orthodontic treatment, and the reasons for this are poorly understood. From the available literature, it is difficult to know whether dentists have sufficient knowledge on graduation in orthodontics, to prepare them for general practice. It would appear that dentists are good at determining treatment need, perhaps perceive their knowledge as deficient, and may have problems applying the knowledge they have to a clinical situation.

The literature review in Chapter 6 explores the relationship between dentists and orthodontic treatment. It includes studies pertaining to undergraduate experience, continuing professional development, orthodontic treatment patterns, dentists' assessment of orthodontic treatment need, and appropriateness of orthodontic referrals.

### **5.2.8 Interviews relating to orthodontics**

Interviews have been used in the field of orthodontics to assess patients' perception of their orthodontic treatment need (Christopherson et al., 2009a, 2009b), and orthognathic patients' perceptions of referral to a mental health professional (Ryan et al., 2009). Christopherson et al. interviewed patients face to face, using dental assistants who had received interviewer training prior to the study. The researchers were keen to explore whether children objectively assessed, and subjectively assessed, orthodontic need, and whether their self-perceptions and desire to have braces varied with age, gender, race and socioeconomic status. The authors concluded that the patients' desire to have braces seemed to be determined not only by need but by age, gender and race. Ryan et al. (2009) investigated orthognathic patients' perception of referral to a mental health professional. The findings from their interviews helped develop a questionnaire. Pilot interviews were first performed to ensure that the topics chosen for the interviews would provide constructive data. Ten patients and ten clinicians were interviewed using semi-structured interviews with open ended questions. Topics were explored as necessary, to determine all themes of interest, and the interviews were taped and fully transcribed immediately after they had taken place. The content was examined and coded, and compared as the interviews took place, and also after data collection was completed. This allowed the authors to raise any additional concepts in subsequent interviews.

The data were analysed using a form of thematic content analysis, where the broad themes were identified initially, and then investigated with the interviewee. Following the interviews and data analysis, a questionnaire was developed to include the most significant features.

### **5.2.9 Summary of the literature**

Face to face interviewing is a common qualitative research method for gaining information from dentists about a wide range of topics. Like any other research tool, analysis of the interview transcripts has to be performed methodically and ideally by more than one researcher. It would appear that thematic analysis is a comprehensive and popular method for analysing the data.

The drawbacks of interviews are; they are time consuming, they are reliant on the interviewees co-operating, there being sufficient numbers participating, and that the interviewer equipped with the skills to be able to explore responses, analyse and identify themes. Knowledge may have a part to play in influencing the behaviour of the dentist, and there appears to be a proportion of dentists who chose not to provide any orthodontic treatment. Self-perception of their capabilities may be low in this area of dentistry.

## **5.3 Aim of the study**

The aim of this study was to gain insight into the attitudes and beliefs of GDPs with regard to interceptive orthodontics, and their role in provision of such treatment, by carrying out semi structured interviews, and performing thematic analysis.

## **5.4 Method**

Semi structured interviews were performed with a convenience sample of GDPs practising across Scotland. They were acquaintances of the researcher. Each GDP was contacted and requested to partake in an interview lasting approximately 15 minutes, arranged at a time convenient to them. All GDPs approached agreed to participate in the interview. Due to the varying location of the dentists, some had face to face interviews, and some were conducted over the telephone. All were recorded, transcribed, and made anonymous within 24 hours of taking place.

The interviews were based around questions which explored GDPs understanding, experience and provision of interceptive orthodontics in general dental practice. A list of the questions can be found in Appendix 4. After seven interviews (three face to face, and four by telephone) it was felt that saturation had been reached, with no new ideas being identified. The transcripts were independently read and re-read by two researchers (FB and DB), to identify common themes and subthemes arising in the responses to the questions. The thematic analysis revealed three main themes, each with subthemes. Following this, a coding framework was established (Table 5.2) by grouping the similar themes and subthemes together, and ordering them numerically. This allowed separate statements in the transcripts to be allocated a code relating back to the framework.

**Table 5.2;** Coding framework developed following thematic analysis.

<b>1. Motivators</b>
1.1 Positive outcomes/belief in success
1.2 Responsibility/duty/role
1.3 Confidence
1.4 Self esteem
<b>2. Barriers</b>
2.1 Experience
2.1.1 Undergraduate level
2.1.2 Postgraduate level
2.2 Lack of knowledge
2.2.1 Solutions
2.3 Lack of confidence (self-doubt)
2.3.1 Solutions
<b>3. Explanations for not providing Tx “excuses”</b>
3.1 The system
3.2 “Crying child” (Pt co-op)
3.3 “It’ll all be alright in the end”/ Refer

Following the development of the framework the transcripts were coded into the categories in the coding framework. Negative and positive statements were associated with the confirmed themes. The process of coding was performed by two researchers (FB and DB), and high intercoder reliability was observed in this process (intercoder reliability statistics were not undertaken due to the small number of coders, and the relatively small amount of data to be coded) as all statements, with the exception of two, were coded in the same manner. These discrepancies were resolved subsequent to discussion, and the coding was completed.

## 5.5 Results

A total of seven GDPs were interviewed, five NHS independent GDPs and two NHS salaried GDPs. The age range was from 27 to 49 years, and there was one male and six female dentists. None of the dentists have a specialist interest in Orthodontics. All dentists frequently treat children, and are based across Scotland. The results are reported according to the developed framework.

### 5.5.1 Motivators for providing treatment

All respondents believed that interceptive orthodontics has a positive outcome/ believe it is successful;

*“Seeing problems early and doing orthodontics treatment to influence the developing dentition or growth pattern.....It should then lessen or even eradicate the problem.” (Interviewee 2)*

All subjects felt that they had a role to play in general practice, with regard to identifying problems that might benefit from interceptive orthodontics. One felt that their role was to refer only, while the other six were willing to provide removable appliances, or carry out extractions without the need for specialist advice;

*“With long waiting lists for orthodontic treatment, I think make it more important that this type of treatment is carried out in practice.” (Interviewee 3)*

*“If I don’t do anything, who will?” (Interviewee 7)*

*“I wouldn’t want to refer something simple and clog up the specialist services.” (Interviewee 2)*

*“....I also would think about the timely extraction of carious 6s along with balancing and compensating. The other thing that I might do, is balance anteriorly, with deciduous extractions, if there was a centre line shift.”*

*(Interviewee 6)*

With regard to the GDPs' confidence, five of them were happy and felt comfortable with treatments they provided;

*“Because it is simple, I am confident doing it and I don't think that much can go wrong.” (2)*

*“I am quite good at timely extractions and thinking about space maintainers.” (3)*

*“I have done in the past and would probably do again....I don't think you can go wrong with that or do any damage....so I am happy to do that.” (4)*

Two expressed the boost to self-esteem that providing the treatment bestowed;

*“I do feel that the simple URA treatment is rewarding.” (2)*

*“If I can help then that's great, and that's what I see.” (1)*

### **5.5.2 Barriers to providing treatment**

Despite all the positivity surrounding the provision of interceptive orthodontics highlighted by the interviews, there were a greater number of negative statements identified. Experience, both at an under-graduate and post-graduate level, was identified as playing a key role in the decision not to provide treatment;

*“My undergraduate teaching wasn't great, there was little hands on, and it was mainly taught from books.” (2)*

*“The teaching wasn't very good.” (5)*

*“If you are a VT (vocational trainee) and you don't do any then, then you are unlikely to start doing any.” (5)*

*“No I didn't do any, my trainer just referred everything in too. I think that has got a lot to do with what I do now.” (6)*

Six of the interviewees then proceeded to mention that their experiences have led to a realisation of a lack of knowledge in this area of dentistry:

*“Knowledge in some situations is limited.” (7)*

*“I wouldn’t understand enough of what I was doing.” (6)*

As a solution to their lack of knowledge, this group of GDPs, felt that a course would be the best way to improve their knowledge. Also, feelings of self-doubt and/or lack of confidence in the field of interceptive orthodontics were identified. All participants displayed feelings in this area:

*“Some areas I feel nervous about and would refer for an opinion.” (7)*

*“The only other obstacle is knowing that you are doing the right thing and not making things worse.” (1)*

*“I probably over refer to be cautious.” (4)*

*“Another thing is that these days patients and parents have such high expectations, and fixed braces are so common. I sometimes think that I can’t meet those expectations, so I will refer.” (2)*

Solutions to self-doubt tended to focus on two main areas, having a treatment plan from a specialist, or having had more practical experience as a student or during VT year;

*“If the design of the appliance was clear, and I knew exactly what they wanted me to do, I would have a go.” (6)*

*“Would be happy to carry out the treatment if I was given a plan by a specialist.” (7)*

*“And it would be good if it could be incorporated into VT, so we then do some in practice and get the experience.” (6)*

### **5.5.3 Explanations for not providing treatment**

The final theme identified was explanations for not providing treatment, or “excuses” for not providing treatment. It was divided into three subthemes; the system, “crying child”, and “it’ll be alright in the end.” Regarding the system, comments were made about the complexity of the paper work, and being at the mercy of the NHS advisors, but nothing was mentioned regarding remuneration.

One interviewee felt keeping all the registered child patients dentally fit was time consuming enough, without having to provide orthodontic treatment.

With regard to the subtheme “crying child” or patient co-operation, only three of the GDPs felt this was a reason for not providing treatment;

*“if it involves extractions, you always have to weigh up upsetting the patient”(2)*

*“...have to spend a lot of time to persuade a child to have an extraction or something done, therefore is it worth it?” (1)*

Five of the participants commented on the fact they felt that problems could be fixed later on by a specialist, if they had missed an opportunity to intercept, or hadn't referred at the correct time;

*“I don't think that six months makes much of a difference regarding referring.”(5)*

*“with what's available with the orthodontists, we can just let things develop and deal with it later.”(1)*

## **5.6 Discussion**

These semi structured interviews provided a wealth of information pertaining to GDPs beliefs about interceptive orthodontics. As previously mentioned, it is important that any other valuable information is not ignored. Other issues that were mentioned on an individual level were as follows;

### **5.6.1 The perception of dental fitness amongst clinicians**

One GDP mentioned that there was insufficient time to be providing interceptive treatment, as keeping the children dentally fit was time consuming enough. It would appear some GDPs perceive the concept of dental fitness as being free of dental disease rather than having a healthy functioning occlusion.

### **5.6.2 Parents and patients high expectations**

One interviewee was reluctant to provide treatment, as they felt they would not satisfy the expectations the parents and patients had regarding the outcome of treatment. With fixed orthodontic appliances having become more socially acceptable, and patients and parents more concerned about dental aesthetics, it may be that intercepting with removable appliances does not fully meet expectations. If the objectives of the URA treatment are explained to patients



and parents, and the option of fixed appliance treatment is still available at a later date, with the likelihood of reduced complexity/length of treatment, this potential barrier could be overcome.

### **5.6.3 Knowledge versus Confidence**

From these interviews it seems that confidence in providing treatment is one of the main factors required for providing interceptive orthodontic treatment.

Confidence is gained through clinical experience, whether that be at undergraduate or postgraduate level. It would seem that we are influenced from an early stage in our careers, and if no clinical experience is acquired at this time it is not sought later on. This is an interesting point, as many new graduates or post VTs will have limited experience in complicated restorative procedures, such as molar root canal treatment, but have the confidence to continue to gain experience, and confidence in providing this treatment in general dental practice. Why is it not the same with interceptive orthodontics?

Although some conclusions can be drawn from this sample, the sample is small, but the researchers felt that saturation had been reached, and further interviews were not going to identify further themes.

It would seem that from this study there are three main themes surrounding the provision of interceptive orthodontics in primary care; motivators, barriers and excuses. The motivators focus around beliefs, the barriers around skills and knowledge, and the excuses around the setting. Therefore, in order to progress this research further, more information was needed from GDPs surrounding these variables, and this was sought by the development and analysis of a paper based questionnaire to a large sample of GDPs across Scotland, as reported in Chapter 6.

## **5.7 Conclusions**

This study is this first piece of work to investigate GDPs attitudes and beliefs towards interceptive orthodontics in primary care, and has provided valuable insight.

From this sample it was identified through thematic analysis that:

- GDPs consider themselves to have an important role in monitoring the developing dentition, and intercepting where necessary;

- Although the GDPs expressed their knowledge to be deficient in the field of interceptive orthodontics, the issue of lack of confidence and experience proved to be a greater reason for not providing treatment;
- Most GDPs feel that malocclusions can be corrected at a later date by orthodontists, if they miss an opportunity to intercept.

## **Chapter 6**

**What may influence the implementation of interceptive orthodontics in primary care?**

## 6.1 Background

As previously mentioned in the introduction of this thesis, there is an inconsistency between what is currently being taught by the Orthodontic and Paediatric staff in the BDS programme at the University of Dundee (regarding the developing dentition/providing interceptive orthodontics) and what is referred to the two units by GDPs.

There appear to be missed opportunities by GDPs, e.g. referring a 14 year old with crowding, whom had undergone root canal treatment of a first permanent molar at the age of ten years old. There is also a lack of awareness of developing problems, e.g. referral to assess crowding in a 12 year old whom on examination of the patient it was not possible to palpate an upper permanent canine and radiographs revealed it to be palatally positioned. A good referral therefore involves three elements (Kisely et al., 1997, Jackson et al., 2009); the severity of the malocclusion (based on IOTN scoring); the complexity of the treatment required (specialist or hospital consultant); and, the timing of the referral.

A needs assessment was performed, in November 2009, to determine the number of new patient referrals to both the Paediatric, and the Orthodontic units at Dundee Dental Hospital regarding issues surrounding interceptive orthodontics (IO). It was decided to examine fifty consecutive new patient referrals, 25 to Paediatrics, and 25 to Orthodontics. Of the 25 referrals to the Paediatric unit, eight contained IO related queries, and of 25 orthodontic referrals seven were interceptive related. The results are presented below (Table 6.1).

**Table 6.1;** Interceptive orthodontic referrals.

<b>Reason for referral</b>	<b>Paediatrics</b>	<b>Orthodontics</b>
Poor prognosis first permanent molars	5	1
Unerupted upper permanent central incisor	1	
Submerging second deciduous molars		1
Non-palpable upper permanent canine	2	2
Single tooth anterior crossbite		1
Thumb sucking habit and anterior open bite		1
Increased overjet and incompetent lips		1
Total	8	7

This indicated that approximately 30% of referrals to DDH Paediatric and Orthodontic units are related to interceptive orthodontics. GDPs are frequently examining patients who require interceptive treatment, and are either requiring advice, or are not willing to provide the treatment. From this, it could be seen that if GDPs could manage developing dentition anomalies successfully, there would be less pressure on the secondary services, enabling a more efficient service.

The following research question was therefore constructed; “What are the knowledge, skills and attitudinal barriers to practicing interceptive orthodontic behaviours in primary dental care?”

In order for current practice to change, it is important to understand the current thinking of GDPs when faced with a variety of scenarios involving IO. Chapter 5 reports the results from semi-structured interviews performed with a small group of GDPs, which begins to unravel some of the barriers to providing interceptive orthodontics (IO) in practice. Using this information, and drawing on the literature, a paper based questionnaire was formulated to capture GDPs behaviours, and begin to understand their attitudes towards IO. This chapter includes a literature review, describes the questionnaire development, content, presentation and analysis of the results.

## **6.2 Literature review**

This literature review covers topics which provide a background to GDPs attitudes towards the orthodontics they learnt as an undergraduate, how they continue to learn through their practising careers (continuing professional development), their perceived barriers to care, their treatment patterns, perceived orthodontic treatment need of patients, and quality of orthodontic referrals. The literature review will also include background on two established psychological theories, the theory of planned behaviour (TPB), and the Social Cognitive Theory (SCT), both of which were used in the development of the questionnaire.

### **6.2.1 Undergraduate experience**

In order to understand current practice in general dental practice, it is worth considering newly qualified dentists’ views on their undergraduate course. Derringer (2005, 2006) has evaluated orthodontic teaching in dental schools

across the U.K, and has found there to be a huge variation in content, length of course (in terms of hours), and in student assessment and examination. Over a decade ago, a study investigated the skills and knowledge vocational dental practitioners acquired as undergraduates in the UK (Murray et al., 1999). Interestingly, only 58% were satisfied with the theoretical information they received in orthodontics. Only 45% felt that their practical orthodontic experience had been relevant to their current practice, and only 46% felt that they would be able treat simple cases with removable appliances. Forty percent of respondents felt that their undergraduate course could have been improved by gaining greater practical experience.

A more recent survey, again looking at undergraduate orthodontic training, examined a group of GDPs who had been practicing for a variety of years, and found 63% were satisfied with the academic component of the orthodontic course, and 54% were satisfied with the clinical component (Fleming and Dowling, 2005). Curiously, 69% felt they were competent at orthodontic assessments and 60% were competent at managing an orthodontic emergency. Both of these (orthodontic assessment and orthodontic emergencies) were learning outcomes in the General Dental Council's document, "The First Five Years" (GDC, 2002) which was the current document at that time, and are still included in the recent document, "Preparing for Practice" (GDC, 2011). Ninety six percent felt they were competent at referring appropriately, and 76% felt they had the knowledge to use removable appliances. However, only 24% would correct an anterior crossbite, and 15% would fit a space maintainer, suggesting that there is a disparity between knowledge and clinical application. It is interesting that 96% of the GDPs felt they were competent at referring appropriately, and it would have been of added value to the study if an analysis of the appropriateness of the referrals had occurred.

Patel et al. (2006) compared the views of new vocational dental practitioners (VDPs), and their trainers, regarding how undergraduate dental education prepared them for their vocational training (VT). They concluded that deficiencies should be targeted during the vocational training year. However, there are likely to be many competing demands during the VT year. Also,

addressing any deficiency is heavily dependent on the trainer having adequate skills to help the VDP.

The Scottish Dental Practice Based Research Network (SDPBRN) surveys final year BDS students, exploring confidence, attitudes, and beliefs towards dental practice. This survey is given to all BDS students in Glasgow and Dundee. The survey is repeated at the end of their VT year. It is unfortunate that the annual publication by SDPBRN does not include any developing dentition scenarios to be able to gauge the confidence of clinicians in this area, before and after their vocational training year.

More recently, a study in Hong Kong has investigated graduates self-perceived preparedness for practice, following the introduction of an integrated problem based learning (PBL) curriculum (Yiu et al., 2012). The mean values of graduates feeling well prepared for orthodontics was 23% ( $\pm 33$ ), and for managing children and special needs patients was 65% ( $\pm 29$ ). Although the authors concluded that graduates felt well prepared for most fundamental aspects of dental practice, the results do not appear to show this.

The literature suggests that confidence is very important in shaping what treatment a GDP will provide. Many dentists feel that the teaching they received as an undergraduate does not prepare them for practice. Although the vocational year provides an opportunity for newly qualified dentist to gain experience and confidence in areas considered deficient, it is heavily reliant on the trainer possessing these skills, and having the time to spend with their VDP.

### **6.2.2 Continuing Professional Development (CPD)**

If dentists feel that they have not gained sufficient knowledge, confidence or hands on experience to provide certain dental treatments, attending a continuing professional development course may be an appropriate means to satisfy these needs. Exploring the literature for studies which investigated dentists and continued learning, several were found, and the key findings are presented in Table 6.2.

**Table 6.2;** Continued learning habits of dentists.

<b>Author &amp; Year</b>	<b>Country</b>	<b>Type of study</b>	<b>Findings</b>	<b>Comments</b>
Seoane et al., 2012	Spain	Questionnaire based	Those attending 4 or more courses were more likely to give alcohol advice and check oral mucosa. Increased experience did not increase probability of preventive attitude.	
Barnes et al., 2012	Europe	Literature Review	Most dentists participate in CPD with course attendance and journal reading most common. Barriers to change include resources and support from colleagues	Variety of quality of studies included
Bahador et al., 2010	Iran	Questionnaire based	Participants comprised of a range of health care providers, including dentists. 47.7% felt that their continuing education programme was effective. Workshops were more effective than seminars (62% versus 30%).	No mention of why they thought continuing education was ineffective.
Hopcraft et al., 2010	Australia	Questionnaire based	Dentist reported attending on average over 30 hours of clinical CPD. 25% dentists mainly attend as it is mandatory. Barriers for rural and female dentists exist	
Maidment et	UK	Questionnaire	GDPs have a varied and inconsistent application of advance in	Would have been worth



al., 2010		based	restorative techniques. Investigating the practices and decision making processes of GDPs would enable a targeted PG educational programme to be created.	repeating the questionnaire after the course.
Navabie and Nazarian, 2010	Iran	Focus groups	GDPs have a need for courses on operative dentistry, root canal therapy and dental prosthesis.	Self-perceived need.
Bullock et al., 2009	UK	Questionnaire based	Dentist participating in a master's programme. The motivation for participating was to improve patient care and most GDPs (95%) made a change to their clinical practice.	
Nieri and Mauro, 2008	Italy	Telephone interviews	GDPs in the province of Prato read Italian journal every week, attend a course every six months and do not read articles published in international journals.	Finding from only one area in Italy.
Chan et al., 2006	Asia (Several countries)	Face to face interviews	Implantology and cosmetic dentistry are the most preferred subjects for courses. Didactic teaching was preferred by most (82%) for PG study.	
den Boer et al., 2006	Netherlands	Questionnaire based	Over a two year period nearly all dentists (93%) had attended one or more courses. They were more interested in attending	No mention of any change to clinical

			course on clinical procedures.	practice
Maidment, 2006	UK	Questionnaire based	Courses were seen as highly effective in changing knowledge and practising behaviour. Course and reading journals best at changing knowledge.	Self-reported.
Burke et al., 2005	UK	Questionnaire based	5% attended no courses in a calendar year, 27% attended one or two courses, 27% attended three or four courses, and 41% attended five or more courses. No significant differences between single-handed and partnership practices, and in relation to practice location.  Relatively few dentists were using on-line CPD at the time of the survey.	
Sutton et al., 2005	UK	Questionnaire based	98.7% of GDPs were motivated to attend CPD courses because of an interest in a particular discipline and only one dentist reported attending out of personal learning needs.	
Tredwin et al., 2005	UK	Questionnaire based	87% dentists agreed/strongly agreed that the BDJ CPD fulfilled their CPD needs. 92% agreed/strongly agreed that their knowledge increased following the BDJ CPD. 72%	Self-reports. No evidence that this resulted in better patient care.

			agreed/strongly agreed that an element of their practice had changed due to BDJ CPD. Journal based learning is an effective was of undertaking verifiable CPD.	
Best et al., 2005a, 2005b	17 Countries	Workshop and questionnaires	Lectures and hands-on skills courses were held in all 17 countries. Very few studies for the effectiveness of dental CPD were identified.	Huge variation between countries and within some countries
Firmstone et al., 2004	UK	Questionnaires and interviews	Course attendance affected practice. Barriers to implementation identified; cost, time, NHS constraints and personal or staff issues.	Self-reflection. No evidence that change to practice actually occurred
Bullock et al., 2003	UK	Questionnaire based, across 3 regions in England	Nearly all GDPs attend CPD courses and read journals. Older dentists were undertook less hours of CPD	Before GDCs compulsory revalidation scheme was introduced
Ruggia, 2003	Switzerland	Questionnaire based	Approximately half of dentists are up to date with training in medical emergencies and their knowledge. Little was found out about the other dentists. The authors propose an e-learning	

			course on medical emergencies	
Leggate and Russell, 2002	UK	Questionnaire based	Nearly all GDPs were participating in some CPD	Before GDCs compulsory revalidation scheme was introduced
Buck and Newton, 2002	UK	Questionnaire based (people on the GDC register)	Those with either PG qualifications, qualified for between 21 and 30 years or had had a career break tended to read journals. Attendance at a course was linked to males, not having a career break and not being a GDP	Limited relevance due to the changes in GDC regulations for CPD.

Few of these studies mention orthodontics specifically. However, the study performed by Sutton et al. (2005), looked at the self-perceived needs of general dental practitioners. With regard to orthodontics only, 11% perceived themselves to have a good level of knowledge, 59% thought it to be average, and 30% poor. For those who felt it to be poor;

- 28% of them felt it was due to lack of clinical practice,
- 25% due to lack of undergraduate training,
- 19% due to lack of postgraduate training,
- 19% lack of interest, and
- 9% was due to lack of patient demand or lack of job satisfaction.

The authors attribute the poor self-perceived knowledge in orthodontics, oral medicine, and dental sedation techniques (which were three out of the four disciplines with the poorest self-perceived knowledge), to the fact they are considered by many dentists to be post graduate disciplines. It may have been better to replace the question “How do you rate your knowledge in the following dental discipline?” with “Compared with your peers or the standard of a newly qualified dentist how do you rate your knowledge in the field of orthodontics?”

It is important GDPs gain the skills they are looking for from attending CPD courses, and that this in turn leads to a change in their clinical practice. Bullock et al. (2003), and Firmstone et al. (2004), have investigated the impact of course attendance on the practice of GDPs, and factors affecting impact. They found a clear link between dentists attending a lot of CPD courses, and high impact on clinical practice.

Dentists’ selection of courses was based mainly on convenience, and their own perceived learning needs. It would have been interesting to explore the idea of perceived learning needs more. For example, some GDPs may not attend a course on interceptive orthodontics, as they don’t perceive themselves to have a learning need, despite sending inappropriate referrals. In the study by Firmstone et al. (2004) they asked the question “Following a continuing educational activity, what barriers or constraints to change have you experienced?” Four main barriers were identified; cost, personal or staff issues, time to implement change, and constraints related to the fee structure within the National Health Service (NHS). It is noteworthy that these

barriers were not the ones identified during the semi structured interviews in this thesis.

The same group of researchers have since looked at courses which are part of a longer-term planned programme of continuing education, and have found that they are more likely to impact dentists' practice, than short course interventions (Bullock et al., 2009). The study assessed the impact of a part-time, five-year Master of Science (MSc) programme, and found that GDPs motivation for participating was to improve patient care, and most GDPs (95%) made a change to their clinical practice. They reported an increase in knowledge and confidence following participation which has led to change in clinical practice for the intended benefit of their patients. Clearly this is a group of highly interested and motivated GDPs, who have chosen to commit to a five year programme of study, and enrolled in the programme to improve patient care by changing their clinical practice. It is likely that it is not the duration of the course, but the attitudes of the GDPs participating, which make the difference.

Looking specifically at dentists' reasons for choosing a particular CPD activity, the following reasons seem to dominate:

- interest in a specific discipline or to improve knowledge or skills in that area (Leggate and Russell, 2002, Sutton et al., 2005, Hopcraft et al., 2008, Hopcraft et al., 2010);
- convenience (Firmstone et al., 2004); and,
- course presenter (John and Parashos, 2007, Hopcraft et al., 2010, Redwood et al., 2010).

### **6.2.3 GDP perceived barriers to providing care**

The work by Bullock et al. (2003), and Firmstone et al. (2004), touched on the possible barriers to changing clinic practice. John and Parashos (2007) have investigated the factors involved in the translation of continuing professional development into clinical practice. Immediately post CPD, nearly all participants felt they could implement what they had learned into clinical practice. Three months after CPD, 90% of those who had attended the course on endodontics, and 53% who had attended the course on implants, felt that their practice had changed as a result of attending their courses. The dentists who reported no change gave the following

reasons; their practices were not equipped to carry out the procedures, the socio-demographics of their practices made it uneconomical to incorporate the concepts learned in the course. Suggestions were given by participants to further impact on their clinical practice. These included supervised clinical treatment with the aid of a specialist, a mentoring process, and courses which cater for different levels of experience, e.g. a beginner, intermediate and advanced course. This is an interesting point as most CPD courses do not take into consideration the variation in skill mix within the audience, and provide one course for all levels of experience.

Specifically relating to orthodontics, there has been a two part article published describing the limiting factors to orthodontic treatment, with part one listing the four main factors; patient factors, operator factors, type of appliance used, and biological factors (Shah and Sandler, 2006). Expanding on the operator factors, these appear to be knowledge and clinical ability, available resources, goals of the operator, and communication skills.

It would seem that there are many perceived barriers to providing treatment, and they are often dependent on the presenting situation. An emerging theme is emphasis on providing more practically based education, be that a hands on course or shadowing session with a specialist. It may be that it is confidence which GDPs are seeking with these courses, rather than the actual practical skills.

#### **6.2.4 Orthodontic treatment patterns**

Sheiham et al. (1971) observed over 40 year ago that a large percentage of GDPs refrained from treating orthodontic patients, and it is still the case today. A study in 1982 endeavoured to identify the factors influencing the amount of orthodontic treatment attempted by recent dental graduates (Brown et al., 1982). The participants had been qualified three to five years. A direct relationship was found between lack of confidence in activating a removable appliance, recognising anchorage loss, and proportion of patients referred to an orthodontist. Confidence was found to play a large role in provision of treatment. This ties in with the findings presented in Chapter 5.

Although the remuneration system is different in the United States, orthodontics is still regarded as a post graduate subject. Wolsky and McNamara Jr (1996) examined the orthodontic treatment provided by GDPs in Michigan. The results revealed that 57% of dentists would provide some form of limited treatment, such as correction of

anterior or posterior crossbite, placement of space maintainers. Nearly 24% provide no orthodontic treatment at all, and 19% provide comprehensive treatment, using fixed appliances.

Interestingly, a study was conducted looking at orthodontists' perspectives on the best time to initiate treatment, amongst other things (Yang and Kiyak, 1998).

Orthodontists would most likely treat half of the presented conditions in the early mixed dentition, especially anterior crossbites (> 76%). Patient factors that precluded treatment were behaviour (98%) and compliance (96%) problems.

Unfortunately, this study is of little benefit as the orthodontists examined were in private practice and likely influenced by financial incentives to starting treatment.

Galbreath et al. (2006) have investigated orthodontic treatment provided by general dentists, this time in Kentucky, and tried to identify variables that influence their treatment patterns. Fifty five percent found their pre-doctoral orthodontic training poor. The most commonly reported treatments were space maintainers (57%), correction of anterior crossbites (37%), minor rotations (36%) and habits (33%).

Forty three percent stated that they provided no orthodontic treatment. Dentists who received more orthodontic continued education were more likely to provide more treatment, and provide complex treatment, compared with those who only had orthodontic education from dental school who were more likely to provide no orthodontic treatment. Also, GDP location and proximity to nearest orthodontist was an influencing factor, with GDPs providing more orthodontic treatment in areas remote from an orthodontist. More recently an email survey has been conducted looking at orthodontic provision by GDPs in New Zealand (Aldawood et al., 2011). Approximately one-fifth of GDPs reported providing some form of orthodontic treatment. These GDPs tended to be was found to be higher among males, more experienced practitioners, and dentists in rural locations.

Although studies have looked at the percentage of dentists providing orthodontic treatment, they have not considered asking those who do not provide treatment why they chose not to. Perhaps, if there was an understanding of the reasons why some dentists are not providing orthodontic treatment, targeted interventions could be developed.



### **6.2.5 Perceived orthodontic treatment need**

Research in Finland has aimed to compare the decisions on need for, and timing of, orthodontic treatment, and the complexity of treatment given by a consultant orthodontist and three public health dentists (Pietilä et al., 1992). Agreement between the orthodontist and the three dentists was fairly good when treatment need was investigated (agreement in 69%, Kappa statistic 0.51). The agreement on timing of treatment was poor (agreement in 49%, Kappa statistic 0.18), with most cases of disagreement having the dentists begin treatment earlier than the orthodontist. The agreement on complexity of treatment was also poor (agreement in 61%, Kappa statistic 0.22), with treatment regarded as more complex by the orthodontist than by the dentists. The study concluded that the dentist should screen children at the age of seven to eight years of age for early orthodontic treatment, but the orthodontist should assess the timing and complexity of treatment. This is a noteworthy finding, as these three aspects of referral, treatment need, the timing of treatment and complexity of treatment are what make a good referral. It is to be expected that the complexity of treatment should have a low Kappa score, as GDPs may not recognise a high anchorage case, or the orthodontic limitations when treating an anterior open bite, but it is concerning that the agreement on the timing of treatment was so poor. Berk et al. (2002) investigated the perception of orthodontic treatment need, comparing orthodontists, paediatric dentists, and general practitioners. The groups were asked to score 137 study models with respect to their need for orthodontic treatment using a seven point scale (1= no need, 7= great need). Comparing the results of paediatric dentists with orthodontists, and comparing paediatric dentists with general practitioners, no significant difference were found. However, the rationale for treatment was not assessed. The study only measured perceived need for treatment, and therefore no assumptions can be made regarding the intention to refer, or timing of referral, all of which impact on the pertinence of the referral.

### **6.2.6 Suitability of orthodontic referrals**

The appropriateness of GDP orthodontic referrals for a new patient consultation was investigated in 1996 in the UK, in two areas of north England (O'Brien et al., 1996). This study showed that there was variation in referral rates between the dentists, and many patients were referred unnecessarily. Importantly, there was no association found between dentists' referral rate and the number of inappropriate

referrals made. The authors concluded that referral guidelines were necessary to reduce the number of inappropriate new patient referrals.

Kisely et al. (1997) also looked at the appropriateness of orthodontic referrals, and access to orthodontic care in an attempt to address a growing waiting list in a UK orthodontic hospital unit. They ascertained 77% of patients were referred to the correct place for their treatment, but 26% were referred at the incorrect time, 8% too early and 18% too late. They recommended the use of protocols to enable GDPs to make more appropriate referrals, and the use of education to improve recognition, management and referral of patients.

A study looking at the effect of provision of orthodontic referral guidelines, on GDP referrals, was conducted in the UK over a decade ago (O'Brien et al., 2000). Of the dentists who received the guidelines, 86% had used them and felt that they had assisted them in making a referral decision, but the results showed the referral guidelines did not have any effect on the appropriateness of referral.

Looking again at the appropriateness of referrals to orthodontists, a study carried out in Singapore found 25% of referrals by dentists were inappropriate, and using IOTN 27% of referrals had either borderline, or no need for treatment (Chew and Aw, 2002).

Some referrals are for advice and to enable a GDP to have a treatment plan confirmed. Bradley et al. (2007) investigated GDPs opinion regarding an online orthodontic referral. Forty six percent of GDPs were interested in using tele-dentistry to obtain a consultant orthodontist's opinion online. GDPs felt this would save time, and achieve a quicker answer to a proposed treatment plan. Perhaps if GDPs had access to an online service, some of the “inappropriate” referrals could be triaged, and not have to have a new patient consultation and assessment.

More recently, Jackson et al. (2009) surveyed orthodontic referral behaviour of general dentists, along with their familiarity with the Index of Orthodontic Treatment Need (IOTN). A paper based questionnaire was used demonstrating 52% of dentists were correct in assessing treatment need, and only 20% of dentists were correct in selecting the correct time for referral. When asked about IOTN; approximately 5% had never heard of it, 42% had heard of it but didn't use it, 46% were occasionally or often using it, and almost 6% always used it (1% did not reply). Curiously, the authors concluded that along with further education, development of referral

guidelines is required, despite the work by O'Brien et al. (2000) showing that guidelines did not reduce the number of inappropriate referrals. They also felt consideration should be given to the use of IOTN as a tool for dentists when making a referral, as there is a large knowledge gap in this area.

Interestingly, looking at referral habits, 55% of GDPs in the Netherlands refer to only one or two orthodontic specialists (De Bondt et al., 2010). The most important factors influencing who to refer to were identified as patient satisfaction, favourable experience in the past, and oral hygiene monitoring by the orthodontist. This was a questionnaire based study. Surprisingly, there was nothing in the questionnaire about quality of the finished occlusion, and the study did not explain what was meant by the phrase "favourable experience in the past."

Finally, a recent study in Brazil has assessed the ability of undergraduates to diagnose a Class II division I malocclusion (Canavarro et al., 2012). The students easily identified an increased overjet but not a bilateral Class II buccal segment. Ninety five percent agreed the treatment was required, and by a specialist, but they were unsure when treatment should start. This again links in with the theme of correct timing of referrals, and if they are unsure as an undergraduate, then they are even less likely to refer at the correct time once in practice.

### **6.2.7 Psychological theories to understand behaviours**

Two established psychological theories, the theory of planned behaviour (TPB) (Ajzen, 1991, Ajzen, 2002) and the Social Cognitive Theory (SCT) (Bandura, 1977, Bandura and Adams, 1977, Bandura, 2004) have been used widely in health psychology, both in the field of medicine and dentistry (Grimshaw et al., 2002, Bonetti et al., 2003, Walker et al., 2003, Bonetti et al., 2005, Eccles et al., 2005, Michie et al., 2005, Bonetti et al., 2006, Eccles et al., 2007, Michie et al., 2008, Bonetti et al., 2009, Clarkson et al., 2009, Bonetti and Blinkhorn, 2010, Bonetti et al., 2010, Grimshaw et al., 2011, Michie and Johnston, 2012,). The TPB suggests attitudes toward behavior, subjective norms, and perceived behavioral control, shape an individual's behavioral intentions and behaviours. The SCT suggests that two main sets of beliefs influence whether or not we perform a behaviour, attitude and self-efficacy.

Perceived behavioural control includes confidence, and items in this area are often aimed at identifying the participant's level of self-efficacy towards performing a

specific behaviour. Subjective norm is determined by a person's normative beliefs about perceived social pressure from significant others, weighted by the person's motivation to comply with those others (Ajzen, 2002). In other words, someone's behavioural intention is influenced by the beliefs of other people, and the weight that person puts on those peoples' opinions. Psychological theories to understand, predict behaviour, and implement behaviour change are explored more in Chapter 8.

#### **6.2.8 Summary of the literature**

From the literature it would appear that newly qualified dentists feel their undergraduate training has failed to provide them with the skills to practise simple orthodontics, and presents them with a barrier to providing treatment. Many GDPs attend courses to address this void, but often the course is poorly delivered, or there are perceived barriers at their place of work, making it impossible to implement change. There appears to be a percentage of GDPs who chose not to provide any treatment, and it is not understood why. Finally, although most dentists recognise when there is a need for treatment, there are a proportion of inappropriate referrals, and often the timing of referral is often wrong. Using the TPB and SCT, exploring dentists' attitudes and self-efficacy towards providing interceptive orthodontic treatment will help to understand the barriers.

### **6.3 Aim of the study**

The specific aim of this study is to further an understanding of what may influence the implementation of interceptive orthodontics in primary care. The findings of this study will inform the development of future intervention(s) to encourage the implementation of interceptive orthodontics in primary care (Chapter 8).

### **6.4 Methods**

It was decided that a paper based questionnaire completed by GDPs would be the best evaluation tool to answer the research question. Semi-structured interviews were performed with a sample of GDPs to gain insight into their perception of interceptive orthodontics, thus enabling the questionnaire to be developed. These interviews are fully reported in Chapter 5.

The participants in this study were general dental practitioners in Scotland. Those who had a patient list with less than 10% children were excluded from this study. It

was felt they would have insufficient exposure to children requiring interceptive treatment as situations requiring interceptive orthodontics occur in only approximately 15 to 49% of children (Popovich and Thomson, 1975, Ackerman and Proffit, 1980, Hiles, 1985).

Advice was sought from the East of Scotland Research Ethics Service (EoSRES) regarding the need for ethical review and they concluded it was not necessary for this project. The response from EoSRES, via email, can be found in Appendix 5.

The questionnaire was structured into three parts;

1. demographics,
2. scenario specific questions, and
3. questions relating to overall confidence, effectiveness, and importance of interceptive orthodontics.

A copy of the questionnaire can be found in Appendix 6.

Six common mixed dentition developmental anomalies were decided upon and picture based scenarios created:

1. Abnormal eruption sequence, with erupted permanent upper lateral incisors and retained deciduous upper central incisors, presenting in a nine year old;
2. An anterior crossbite of the upper right permanent central incisor, in a nine year old;
3. Carious lower first permanent molars, in a ten year old, reporting of sensitivity to cold from these teeth;
4. An increased overjet, in a ten year old, in a boy who plays a lot of sport;
5. A marked anterior open bite, in a ten year old, who has a digit sucking habit; and,
6. An infraoccluded lower right second deciduous molar, with fully erupted lower left second premolar, in a 13 year old female.

All patients were assumed to be medically fit and well, with no congenitally missing teeth. One additional scenario (Scenario 7) was included which did not require any intervention at the age of presentation, but needed to be kept under review. It was of a five year old, in the deciduous dentition, with a significant anterior open bite and no history of digit sucking. Each scenario comprised of a photo illustrating the malocclusion, and two to three sentences describing the condition.

A range of 22 behaviours were listed as possible answers to each scenario. To assess the dentists' behaviour the following question was asked; "Which procedures *would*

you carry out in your practice for this patient?” The question was changed to “Which procedures do you think *should ideally* be carried out for this patient?” to assess knowledge. For attitude the question was “Which procedures do you feel are out-with the scope of general dental practice?”

Following each scenario there were six further questions to be answered using a 1 to 10 Likert scale, with 1 = not at all and 10 = extremely:

1. How confident are you that you have designed an effective treatment plan for this patient?
2. How confident are you that you can effectively carry out your treatment plan for this patient?
3. How effective do you think your treatment plan can be in preventing the need for further orthodontic treatment for this patient?
4. How important do you think it is to carry out interceptive orthodontics for this patient in primary care?
5. How likely is it that this patient would be better off if you did not carry out any interceptive treatment?
6. How confident are you that the procedures you have ideally chosen for this scenario are correct?

Questions one, two, and six related to self-efficacy, and questions three, four, and five related to attitude. Also, a question was included to gauge how many similar malocclusions presented to the GDP in the last six months.

A third section was created in the questionnaire, using similar questions to above, but not relating specifically to a scenario, e.g. How confident are you that you can formulate effective interceptive orthodontic treatment plans for your primary care patients? A final question was added relating to sufficient remuneration for providing interceptive orthodontics in general practice. This section was created to acquire a global understanding of GDPs self-efficacy, attitude and confidence towards interceptive orthodontics.

The questionnaire was constructed, and was sent to a pilot group of six GDPs at the beginning of February 2010. A few minor revisions were made to the questionnaire, clarifying the instructions and scenarios. The questionnaire was finalised and sent to GDPs in a pre-paid envelope. Questionnaires were initially sent on the 4<sup>th</sup> June

2010, with a reminder sent on the 25<sup>th</sup> June 2010, followed by a postcard reminder on the 19<sup>th</sup> July 2010.

It was decided to obtain an expert opinion from Consultant Orthodontists against which to compare the GDPs knowledge, and remove any researcher bias. Seven practising Consultant Orthodontists from across the UK were given the seven scenarios, and asked which behaviours they felt a GDP should be exhibiting for each, and a consensus opinion was sought. They were also asked whether or not the scenario should be managed in practice, or be referred for specialist care.

## **6.5 Sample Size**

A preliminary power analysis suggested that a minimum sample of 146 GDPs was required, to detect a medium effect size of 0.15, in a regression equation with six predictors (knowledge, confidence in ability to design a treatment plan, confidence in ability to effectively treat, confidence in knowledge, attitude toward treatment effectiveness, attitude toward treatment importance):  $\alpha = .05$ , power = .95 (Faul et al., 2007).

Recent studies with GDPs suggest a wide variety of response rates, from 41 to 83% (Allen, 2010, Cherry et al., 2012, Humza Bin Saeed et al., 2012, Laud et al., 2012, Singh et al., 2012), and it was hoped that a 50% response rate would be achieved. However, it was recognised that it was quite a detailed questionnaire, which, although it had a standard framework, may appear time consuming to GDPs. A sample of 400 GDPs was randomly selected from the MIDAS data base, using a list of random sampling numbers, and the GDPs were invited to participate.

MIDAS is the Management, Information and Dental Accounting System. It is a computerised payment processing system processes, which validates dental claim forms for payment, implementing the rules and regulations from the Statement of Dental Remuneration, in Scotland. MIDAS also generates reports for monitoring payment activity, as well as providing profiles of treatment activity.

## **6.6 Measures**

The outcome measure was determined as the intention to provide the correct behaviour, with different treatments appropriate for each scenario. Actual behaviour

was not the outcome measure, as there was no way of collecting this information accurately either from the GDPs, their records, or from dental practitioner services. The independent variables (predictive measures) were created for each scenario, and comprised of the following:

1. self-efficacy;
  - a. confidence designing plan,
  - b. confidence carrying out plan,
  - c. confidence in answer
  - d. self-efficacy indirect total (design plan + carry out plan + confidence in answer),
2. attitude;
  - a. effectiveness of plan,
  - b. importance of interceptive orthodontics for this patient,
  - c. how likely patient is worse off if you did nothing (risk),
  - d. attitude indirect score (effectiveness of plan + importance + risk).
3. knowledge score (what they should do for the patient).

Using section three of the questionnaire, overall general variables were created:

1. overall general self-efficacy (design plans + carry out plans + unco-operative children);
2. overall general attitude (effectiveness of interceptive orthodontic + importance of interceptive orthodontics + worse off if did nothing).

## **6.7 Analysis Plan**

Following the return of completed questionnaire, the data was entered into SPSS v 19. Data set cleaning was performed, and substituting missing items with individual item means was carried out provided two or fewer items from that measure were missing. Data was examined for normal distribution and no outliers were found.

### **6.7.1 Consultant Consensus Opinion**

From the seven Consultant Orthodontists who completed the questionnaire, it was possible to determine which scenarios should be referred, and which could be managed in general dental practice (Table 6.3).



**Table 6.3;** Consultant consensus opinion for the questionnaire scenarios.

<b>Scenario</b>	<b>Consultant Consensus</b>	<b>Number of Consultants in agreement</b>	<b>Core treatment to be provided</b>
1 – abnormal eruption sequence	Refer	6	N/A
2 – anterior crossbite in 9yr old	Treat in practice	7	Provision of a URA
3 – carious lower FPMs in 10yr old	Treat in practice	5	Extraction of permanent tooth
4 – increased OJ, plays sport	Refer (for malocclusion)	7	Provide a mouthguard to prevent trauma
5 – AOB, digit sucking habit	Treat in practice	7	Provision of a thumb sucking deterrent appliance
6 – infraoccluded LRE, erupted LL5	Treat in practice	7	Extraction of the LRE
7 – AOB, 5yr old, no habit	Treat in practice	7	Monitor

The expert consensus opinion was used to score the scenarios for knowledge and behaviour. Table 6.4 shows the scoring system used for marking the knowledge responses for the scenarios.

**Table 6.4;** Scoring system for knowledge for scenarios 1 to 7.

<b>Behaviour</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>	<b>Scenario 4</b>	<b>Scenario 5</b>	<b>Scenario 6</b>	<b>Scenario 7</b>
Refer to a specialist for Rx	Yes			Yes			
Take an impression		Yes		Yes	Yes		
Take a radiograph*	Yes		Yes	Yes		Yes	
Explain the benefits/risks of treatment		Yes	Yes	Yes			
Check for mobility of a decid tooth	Yes					Yes	
Diagnose a digit sucking habit					Yes		
Design & Fit (D & F) a URA		Yes					
Extract a permanent tooth			Yes				
Extract a deciduous tooth						Yes	
Palpate for an unerupted tooth	Yes					Yes	
D & F a digit sucking deterrent appliance					Yes		
D & F a sports mouthguard				Yes			
D & F a functional appl.				Yes			
Provide instructions for appliance		Yes		Yes	Yes		
Continue to monitor developing dentition	Yes	Yes	Yes	Yes	Yes	Yes	Yes

\*Although there were three radiograph options on the original questionnaire, the data was recoded appropriately, to reflect that different combinations were acceptable.

For example, Scenario six, a submerging lower left second deciduous molar, accepted answers were either 5 or 6 (take a periapical or OPT, but not take an upper anterior occlusal radiograph), but not both.

The consensus opinion was also used to develop a scoring system for the behaviour intention score per scenario. A key behaviour was identified for each scenario and additional marks were given if this behaviour had been chosen. Negative marking was used on answers to questions where providing the behaviour would have been harmful to the patient, in that specific scenario. For example, extracting a permanent tooth for the patient in Scenario 1 (abnormal eruption sequence) would have been detrimental. Behaviours which were correct, but not fundamental to the scenario, had a single mark allocated. Lastly, behaviours which were not correct, but caused no harm, were assigned no marks. It was hoped that this scoring would differentiate amongst three categories of GDP; inadequate, average, and superior providers of IO. Table 6.5 shows the scoring system that was used, with the key behaviours for each scenario in bold. The lowest number was assigned to the answer if the GDP was incorrect, and the higher number if they were correct.

All data was recoded to reflect the “correct answers” for the knowledge section, and a knowledge score per scenario and overall was created. Behaviour scores per scenario were created along with an overall behaviour score.

**Table 6.5;** Scoring system for the simulated behaviour score, per scenario

<b>Behaviour</b>	<b>Scenario 1</b>	<b>Scenario 2</b>	<b>Scenario 3</b>	<b>Scenario 4</b>	<b>Scenario 5</b>	<b>Scenario 6</b>	<b>Scenario 7</b>
Refer for treatment	<b>0 / 4</b>	-2 / 0	-2 / 0	0 / 2	-1 / 0	-1 / 0	-1 / 0
Refer for plan		0 / 1					-1 / 0
Take an impression		0 / 1			0 / 1		
Take an OPT	0 / 1		<b>0 / 2</b>			0 / 1	-1 / 0
Take a periapical radiograph						0 / 1	-1 / 0
Explain benefits/risks		0 / 1	0 / 1				
Check for mobility of teeth	0 / 1					0 / 1	
Design & fit a URA		<b>0 / 4</b>					
Xtn deciduous tooth					-1 / 0	<b>0 / 2</b>	
Xtn permanent tooth	-2 / 0		<b>0 / 2</b>	-2 / 0	-1 / 0	-2 / 0	
Palpate for unerupted tooth	0 / 1					0 / 1	
Design & fit a deterrent appliance					<b>0 / 4</b>		
Design & fit a sports mouthguard				<b>0 / 4</b>	-1 / 0		
Provide instructions for appliance		0 / 1			0 / 1		
Nothing	-2 / 0	-2 / 0	-2 / 0	-2 / 0	-1 / 0	-2 / 0	0 / 2
Monitor							<b>0 / 4</b>
Range of total score for Scenario	-4 to 7	-4 to 8	-4 to 5	-4 to 6	-5 to 6	-5 to 6	-4 to 6

Following this, internal reliabilities were calculated for each variable, scenario specific and generally, where applicable, generating Cronbach's alphas. Frequencies (descriptives) were generated for each variable. Any variable, which, if removed, would increase the alpha, was removed.

Correlations were subsequently performed with the overall behaviour score, knowledge and the 16 belief variables;

- three self-efficacy scenario specific (confidence designing plan, confidence carrying out plan, and confidence in answer),
- three attitude scenario specific (effectiveness of plan, importance of interceptive orthodontics for this patient, how likely patient is worse off if you did nothing),
- three self-efficacy from the general section of the questionnaire
- three attitude from the general section of the questionnaire,
- self-efficacy indirect (combined answers from the three self-efficacy scenario specific variables),
- attitude indirect (combined answers from the three attitude scenario specific variables),
- overall general self-efficacy, and
- overall general attitude.

The behaviour intention score was used as the independent variable. A stepwise regression analysis was completed, using any positive correlations which were found from the correlation between the behaviour score (independent variable) and any of the dependent variables.

## **6.8 Results**

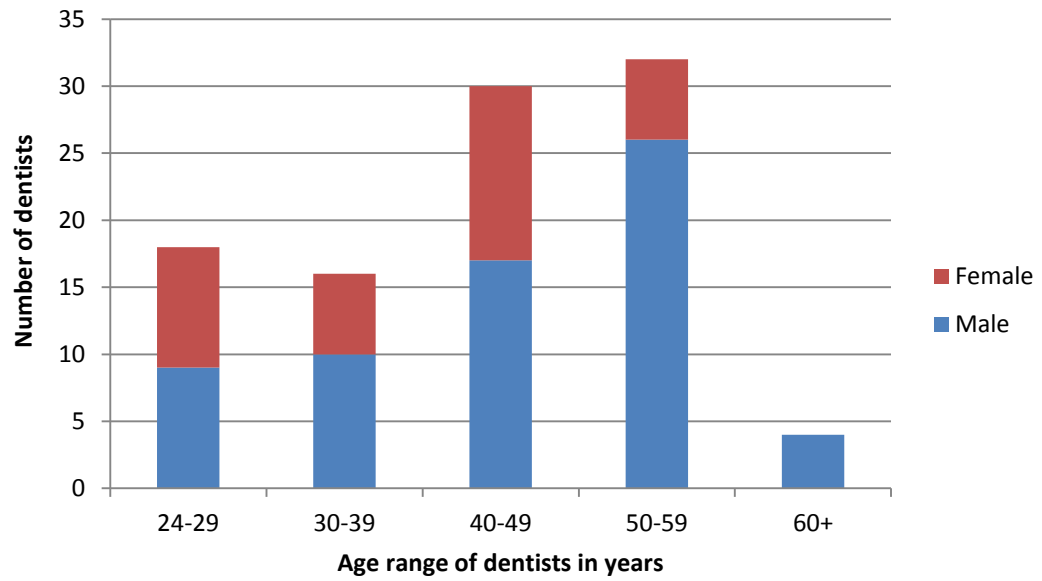
There were a total of 118 questionnaires returned: 101 completed; six where the GDP had either retired or didn't complete; and eleven marked 'gone away' by Royal Mail. An attempt was made to contact 110 of the non-responders to try and get an understanding why GDPs were not willing to complete the questionnaire. The results are displayed in Table 6.6.

**Table 6.6;** Non-respondents reasons for not completing the questionnaire.

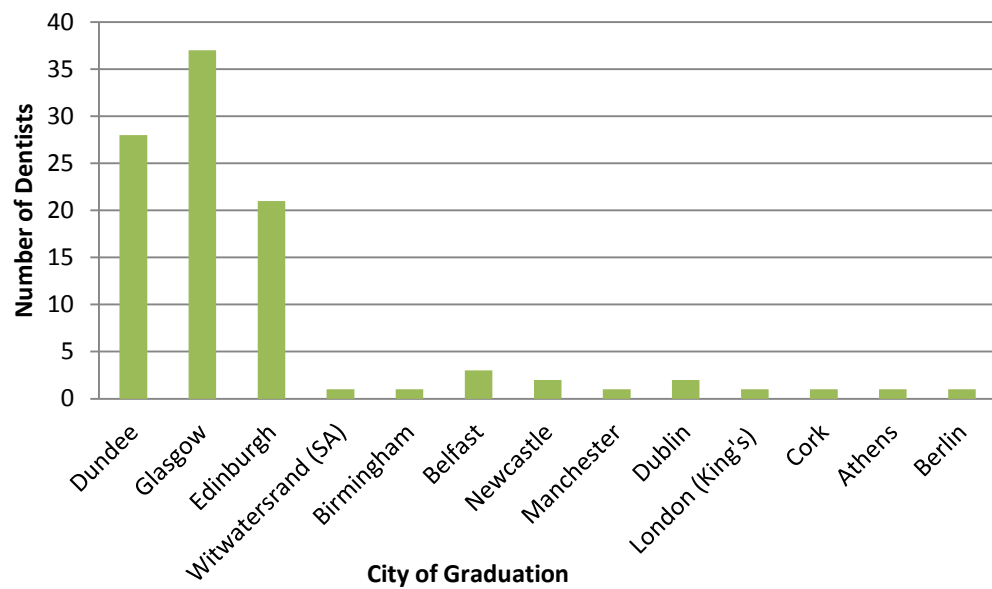
<b>Reason for not completing the questionnaire</b>	<b>Number of GDPs</b>
Too busy	14
Not working there any more	21
Maternity leave	4
Practice closed/dentist on A/L	5
Felt the questionnaire was too long	3
Questionnaire was not clear	3
Specialist orthodontist	4
Not interested in completing it	3
Will complete it (but now too late)	3
Unknown (GDP did not return call)	50

### **6.8.1 Demographics**

Of the 101 completed questionnaires, 1 participant completed all of the questionnaire apart from the demographics, but it was decided to include their responses. From the available data for demographics (n=100) the sample consisted of 66 males and 34 females, with an age range of 24 to 74 years, mean 43.2 years. Ninety two worked in the general dental services, with seven based in the community services and one in a mixed post. Fifty two completed vocational training and 48 did not. Below are figures showing the age and gender distribution of the participating dentists (Figure 6.1), and the city where they graduated (Figure 6.2).



**Figure 6.1;** Number of dentists by age group and gender.



**Figure 6.2;** Numbers of dentists by place of graduation.

### 6.8.2 Frequency of presenting malocclusion

GDPs were asked to state approximately how many patients in the last six months had presented with the problem depicted in the scenarios (Table 6.7). Missing items were not substituted with means for this section.

**Table 6.7;** Frequency of presenting malocclusion over a six month period.

Scenario	Minimum	Maximum	Mean (SD)
1 – abnormal eruption sequence	0	80	1.73 (9.61)
2 – anterior crossbite in 9yr old	0	10	1.46 (1.58)
3 – carious lower FPMs in 10yr old	0	85	8.41 (11.43)
4 – increased OJ, plays sport	0	30	3.46 (4.10)
5 – AOB, digit sucking habit	0	10	1.49 (1.86)
6 – infraoccluded LRE, erupted LL5	0	10	1.64 (1.92)
7 – AOB, 5yr old, no habit	0	20	1.41 (2.86)

### 6.8.3 Remuneration

GDPs were also asked whether, in general, they felt they are sufficiently remunerated for providing interceptive orthodontics in general practice, and revealed 21 felt they were and 80 felt they were not. Frequencies were generated showing the mean score for behaviour intention was very similar, regardless of whether or not GDPs felt they were sufficiently remunerated (Table 6.8).

**Table 6.8;** Comparing opinion on remuneration with behaviour score.

	N	Minimum Score	Maximum Score	Mean Score	Std. Deviation
Not enough £	80	32.22	96.67	61.53	16.78
Enough £	21	35.56	93.89	63.02	18.31

### 6.8.4 Knowledge and Behaviour Scores

Using the expert opinion, the mean knowledge scores and behaviour scores were created for the seven scenarios, and are presented below in Tables 6.9 and 6.10.



**Table 6.9;** Knowledge scores per scenario (n=101).

<b>Scenario</b>	<b>Mean (SD)</b>	<b>Range</b>	<b>Minimum</b>	<b>Maximum</b>
<b>1</b>	15.34 (3.41)	18.00	4.00	22.00
<b>2</b>	14.44 (3.93)	16.00	6.00	22.00
<b>3</b>	12.45 (3.15)	18.00	1.00	19.00
<b>4</b>	10.30 (4.29)	20.00	0.00	20.00
<b>5</b>	13.42 (3.19)	16.00	6.00	22.00
<b>6</b>	13.36 (2.77)	16.00	4.00	20.00
<b>7</b>	18.80 (2.82)	14.00	8.00	22.00

**Table 6.10;** Behaviour scores per scenario (n=101).

<b>Scenario</b>	<b>Mean (SD)</b>	<b>Range</b>	<b>Minimum</b>	<b>Maximum</b>
<b>1</b>	4.15 (2.24)	9.00	-2.00	7.00
<b>2</b>	3.21 (3.69)	10.00	-2.00	8.00
<b>3</b>	0.91 (1.03)	6.00	-2.00	4.00
<b>4</b>	4.51 (1.97)	8.00	-2.00	6.00
<b>5</b>	1.88 (2.35)	8.00	-2.00	6.00
<b>6</b>	2.66 (1.36)	6.00	0.00	6.00
<b>7</b>	3.01 (2.10)	8.00	-2.00	6.00

### 6.8.5 Cronbach's Alphas

A Cronbach's alpha was generated for total knowledge scores, using the seven scenarios, and revealed Scenario 7 to be reducing the value. The Cronbach's alpha with all seven scenarios = 0.566. Table 6.11 shows what happens to the alpha if different scenarios are removed. Scenario 7 had been included as a "red herring," as no treatment was needed. It was therefore decided to remove this scenario from any further analyses and create a total knowledge score with six scenarios.

**Table 6.11;** Cronbach's alphas for knowledge, if various scenarios are removed from the analysis.

Scenario	Cronbach's Alpha if Item Deleted
1	0.58
2	0.42
3	0.50
4	0.47
5	0.49
6	0.51
7	0.65

A Cronbach's alpha was generated for overall behaviour score using the remaining six scenarios, and resulted in very poor internal consistency. Removing the scenarios which were reducing the alpha, until there were no scenarios in the "Cronbach's alpha if item deleted" column that were greater than the overall Cronbach, gave an overall alpha of 0.532. This resulted in only three scenarios being included in further analyses, Scenarios 2, 5, and 6. The discussion contains possible explanations for this. All variables were recalculated to include data from only three scenarios, and the behaviour intention score was converted to a percentage.

#### **6.8.6 Correlations**

A Pearson's correlation analysis was performed to examine the relationship between the outcome variable of behavioural intention to provide interceptive treatment, and the predictive variables. The results are displayed in Table 6.12. For completeness age and gender were also included.

**Table 6.12;** Descriptive statistics and Pearson correlations of predictive measures (independent variables) and behaviour intention (dependent variables).

<b>Predictive measures (Independent Variables)</b>	<b>Descriptive Statistics</b>			<b>Pearson's correlation</b>
	Cronbach's Alpha	Range	Mean (SD)	Intention
Behaviour intention score (%)	0.53	32.22 - 96.97	61.84 (17.03)	1.00
Self-efficacy indirect	0.94	1 – 10	7.72 (1.59)	0.363**
• Self-efficacy design	0.77	3 – 10	7.75 (1.58)	0.334**
• Self-efficacy carry out	0.73	3 – 10	7.72 (1.75)	0.377**
• Self-efficacy answers	0.85	3 – 10	7.69 (1.66)	0.326**
Attitude indirect	0.80	2 – 10	7.36 (1.39)	0.145 ns
• Attitude effect	0.56	3 – 10	6.67 (1.68)	0.051 ns
• Attitude important	0.62	1 – 10	7.73 (1.59)	0.224*
• Attitude risk	0.67	3 – 10	7.68 (1.68)	0.097 ns
Self-efficacy general	0.85	1 – 10	5.11 (2.13)	0.398**
• SE general design	n/a	1 – 10	6.06 (2.49)	0.413**
• SE general carry out	n/a	1 – 10	6.06 (2.49)	0.413**
• SE unco-operative child	n/a	1 – 9	3.22 (2.14)	0.232*

Attitude general	0.79	2 – 10	6.77 (1.79)	0.328**
• Att general effect	n/a	1 – 10	5.93 (2.24)	0.295**
• Att general important	n/a	1 – 10	7.24 (2.22)	0.316**
• Att general worse off	n/a	2 – 10	7.14 (1.93)	0.209*
Total knowledge	0.52	10 – 58	41.21 (7.44)	0.347**
Gender	n/a	1 – 2	1.34 (0.48)	0.116
Age of participant	n/a	24 – 64	43.07 (11.01)	0.399**

\*\*Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

ns - not significant at the 0.05 level

Both self-efficacy general design, and self-efficacy carry out, resulted in the same values. Consulting the correlation table showed these two variables had a high correlation to each other (high bivariate correlation), indicating that the participants had difficulty differentiating between the two questions.

#### 6.8.7 Regression Analysis

An exploratory stepwise multiple regression analysis was performed, inputting the variables from the correlation which were highly significant, along with the dependent variable of behaviour intention score. The following were inputted; self-efficacy indirect, self-efficacy general, attitude general, knowledge, and age.

Adjusted R square = 0.33;  $F_{3,97} = 17.4$ ,  $p < 0.0005$  (using the stepwise method).

Significant variables are shown below.

**Table 6.13:** Significant variables used in exploratory regression, and contribution of each to the model.

Predictor Variable	Beta	<i>P</i>
Age	0.305	$p < 0.001$
Knowledge	0.348	$p < 0.0005$
Self-efficacy general	0.269	$p < 0.003$

Self-efficacy indirect (made up from self-efficacy design, self-efficacy carry out and self-efficacy answers) and attitude general (made up from attitude general effectiveness, attitude general important, and attitude general worse off) were found not to be significant predictors in this model.

Following this, the individual variables, which made up self-efficacy general, which were significant from the correlation, were input in a second regression. This was to try and identify which particular aspect of general self-efficacy was helping to drive the intention of behaviour. However, the correlation had shown self-efficacy general design, and self-efficacy general carry out, to have a high bivariate correlation, and only one needed to be input into the regression. Therefore, SE general carry-out and SE unco-operative child were used, along with knowledge and age. The results for this regression are displayed in Tables 6.14 to 6.16.

**Table 6.14;** Significant variables entered in Stepwise regression.

Model	Variables Entered
1	Self-efficacy general carry out (SEcarrygen)
2	Total Knowledge (TotalKnow)
3	Age

**Table 6.15:** Model summary, including the adjusted R square.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.41 <sup>a</sup>	0.17	0.16	15.59
2	0.53 <sup>b</sup>	0.29	0.27	14.55
3	0.60 <sup>c</sup>	0.36	0.34	13.87

a. Predictors: (Constant), SEcarrygen

b. Predictors: (Constant), SEcarrygen, TotalKnow

c. Predictors: (Constant), SEcarrygen, TotalKnow, Age

As all three variables were shown to account for some of the variance, model three was accepted.

**Table 6.16;** ANOVA, assessing overall significance of the model.

Model		Sum of Squares	Df	Mean Square	F	Sig.
3	Regression	10332.56	3	3444.19	17.90	0.000 <sup>c</sup>
	Residual	18662.96	97	192.40		
	Total	28995.52	100			

a. Predictors: (Constant), secarrygen

b. Predictors: (Constant), secarrygen, TotalKnow

c. Predictors: (Constant), secarrygen, TotalKnow, Age

d. Dependent Variable: globalBSpercent

From this second regression the results can be summarised as follows; adjusted R square = 0.34;  $F_{3,97} = 17.9$ ,  $p < 0.0005$ . Significant variables are shown below.

**Table 6.17;** Contribution of each variable to the model.

Predictor Variable	Beta	<i>P</i>
SE general carry out	0.29	$p < 0.002$
Knowledge	0.35	$p < 0.0005$
Age	0.29	$p < 0.001$

From these results it can be seen that three variables; general self-efficacy regarding carry out the treatment plan, knowledge, and age account for 34% of the variance of the behaviour intention. The self-efficacy component accounts for approximately 16% of the variance, knowledge 11%, and age 7%.

A backwards stepwise regression was subsequently carried out in-putting self-efficacy indirect, self-efficacy general, attitude general, SE general carry-out, SE unco-operative child, knowledge, and age, and the same results were produced.

## 6.9 Discussion

### 6.9.1 Response rate

Although the response rate was low, 25%, it was felt that there was sufficient data to analyse and no need to send out further questionnaires to a second sample. It was felt from the responses received there was sufficient diversity in the demographics for the data to be generalizable throughout Scotland. Consulting a recent NHS dentistry document (NHS Education for Scotland, 2012), the median age of NHS dentists in 2011 was 40, with almost 45% female and 10% qualifying in the European Economic Area. This study had a median age of 44.5 years, 34% were female, and six percent were from EEA.

In hindsight, the questionnaire was probably slightly too long, this could account for the low response rate, but in order to answer the research question as fully as possible a detailed questionnaire was needed. Secondly, there was no incentive offered for completion of the questionnaire, which may have helped to increase the response rate. Although, a recent publication has shown that incentives fail significantly to improve response rates (Glidewell et al., 2012). Thirdly, the timing of the questionnaire overlapped with the start of the school holidays, and it may have been that some GDPs were away and on return the questionnaire found its way to the bottom of the “to do list.” Another factor was the number of GDPs not working at given addresses. Approximately 20% of the GDPs who had failed to return the questionnaire had moved.

### **6.9.2 Expert opinion**

Seven Orthodontic Consultants completed part of the questionnaire, the column in the scenario based sections of the questionnaire headed “Which procedures do you think should ideally be carried out for this patient?” This generated an expert consensus opinion against which the GDPs knowledge could be marked. It was interesting that there was not always agreement amongst the experts, and possible reasons for this may be due to different interpretations of the questionnaire scenarios, but may also reflect on the low level of evidence surrounding the management of these presenting malocclusions. If the experts can not unanimously agree, it is not surprising that GDPs struggle to carry out the correct treatment.

### **6.9.3 Knowledge scores**

It is difficult to explain why the knowledge score for scenario seven caused the Cronbach’s alpha (internal consistency) to lower, but looking at the descriptives, this was the scenario they answered the best. It required the dentist to actively do nothing, so if there were no ticks in the boxes of that column the score was high. Therefore, in hindsight, this was not accurate at predicting how well a dentist would score overall for knowledge. If the dentist was unsure of the answer and ticked nothing, they would have scored well, but in other scenarios, where more boxes were required to be ticked, ticking nothing would give a poor score.

### **6.9.4 Behaviour scores**

Marking the behaviours for each scenario proved challenging. It was important that this was marked differently from the knowledge section, particularly as the experts had determined certain scenarios to be out-with the scope of general dental practice



(scenarios 1 and 4). Unlike the knowledge scores, where the data was recoded positively when GDPs had chosen the right answer and neutral if wrong, the behaviour score used negative marks if it was felt performing a particular behaviour was detrimental to the patient.

It was disappointing to observe such a low Cronbach's alpha for the overall behaviour score, when all the scenarios were included, and ultimately only three were used for further data analysis (scenarios 2, 5, and 6). Looking back at the excluded scenarios, there are possible explanations for having to exclude them.

*Scenario 1 (unerupted upper central incisors in a nine year old)*

The experts wanted GDPs to refer the patient in this scenario, not to take out deciduous teeth, or do nothing. Perhaps with the title of the questionnaire being "Interceptive orthodontics in general dental practice", and this being the first scenario, it pushed the GDPs into ticking a box to do something, despite the instructions asking them to report what they would do for the patient.

*Scenario 3 (carious first permanent molars)*

On reflection this scenario was poorly written and the majority of GDPs chose to restore the teeth, rather than extract them, which was the correct behaviour. Photographs with evidence of more decay, and changing the symptoms to reflect irreversible pulpitis should have been given.

*Scenario 4 (increased overjet)*

This scenario had the least agreement amongst the experts, and this was again probably due to the information given, but the majority chose to have this patient referred. The overjet described was 6mm, which is increased, but not greatly. The male patient was only ten years old, a few years yet from his peak growth spurt, if considering a functional appliance. Also, there is no mention of him suffering any teasing from his peers, which would influence the choice of when to treat him. A better example would have been a 12 year old male with a 9mm overjet.

In order to prevent some of these mistakes, piloting the questionnaire with a group of experts should also have been undertaken. Another explanation for the lack of internal consistency is orthodontists and paediatric dentists perceive managing the developing dentition as one entity. This encompasses ensuring good dental health, monitoring normal eruption sequence, palpating for unerupted teeth at the appropriate time, detecting and managing digit habits, if necessary extraction of teeth at an appropriate time and provision of removable appliances to correct simple

malocclusions. The overall aim is a patient with a healthy dentition, who has not missed any opportunity to lessen the need for complex orthodontic treatment. It is likely that GDPs consider interceptive orthodontics as multiple activities, with no over-riding theme, therefore there is little internal consistency.

#### **6.9.5 Correlations and Regressions**

Out of the four main belief variables, three were significantly correlated with behaviour intention; self-efficacy indirect, self-efficacy general and attitude general, but attitude indirect was not correlated. Inputting these into a stepwise regression showed that general self-efficacy could account for 15% of the variance determining behaviour intention. Breaking down general self-efficacy into the three questions used to create it, and inputting these into a second regression, showed specifically that self-efficacy carrying out IO procedures could account for 16% of the variance. Knowledge and age could account for a further 18% of the variance (increasing age being correlated with a higher behaviour score).

Multiple factors influence behaviour. Factors include socioeconomic status (education, income and occupation), skills, culture (accepted norms), beliefs, attitudes, values, religion and gender (Hayden, 2009). Many of these were not investigated in this questionnaire, as they are not possible to change (e.g religion). In view of this, it was reasonable to have been able to account for up to 34% of the variance associated with the behaviour variable.

#### **6.9.6 Other findings**

It was alarming to find that two GDPs alleged that they had seen 50 or over (50 and 80) patients presenting with delayed eruption of upper permanent incisors over the last six months. This seems a particularly high incidence. It was proposed that they had perhaps misinterpreted the scenario, their knowledge scores were re-examined, and they scored 11 and 15 respectively (both within one SD of the mean).

It is not surprising to find that 80% of the GDPs felt they are not sufficiently remunerated for IO procedures, however this had very little effect on the behaviour intention score.

## 6.10 Conclusions

This would appear to be the first piece of research looking at identifying barriers to providing interceptive orthodontics by general dental practitioners. It was challenging designing this questionnaire as it was attempting to explore, theoretically, dentists' behaviours using simulated scenarios. From this research it would appear that:

1. There is scope to improve the provision of IO in primary care;
2. The biggest barrier to providing interceptive orthodontic care in general dental practice, is confidence relating to how effectively the plan can be carried out for the patient (or designing the plan), and explains 16% of the variance; and,
3. Knowledge also plays a part in acting as a barrier accounting for a further 11%, and age explaining a further 7%.

The next step is to design an intervention aimed at encouraging GDPs to provide IO in primary care, by increasing their self-efficacy associated with designing and carrying out their treatment plans, and improving their knowledge in the field on IO. The proposed intervention is described in Chapter 8. Prior to describing this plan, the following chapter will consider whether there would be any financial saving to the NHS if GDPs were to change their behaviour.

## **Chapter 7**

### **Cost analysis of interceptive orthodontics for thumb sucking habits**

## 7.1 Background

It is well accepted that a prolonged non-nutritive sucking habit (NNSH) can cause a malocclusion (Klocke et al., 2002, Vázquez-Nava et al., 2006). The placement of an object (usually a digit), behind the upper incisors, causes proclination of these teeth often with retroclination of the lower incisors. The object can also prevent eruption of the upper and lower incisor teeth, leading to the development of an anterior open bite (AOB), and specifically, prolonged digit habits are associated with an increased overjet (Bishara et al., 2006, Ogaard et al., 1994). These problems can be difficult to manage orthodontically, and usually require fixed appliance treatment (Petrén and Bondemark, 2008) or in more severe cases, orthognathic surgery. Following treatment, there can be relapse, and the AOB can re-establish itself. Research in Germany has shown that up to 40% of AOB patients who are treated with a combination of orthodontics and surgery have an improvement in the overbite, but do not achieve an excellent outcome at the end of treatment (Jensen and Ruf, 2010). Combined orthodontic/orthognathic treatment is not only risk-associated and time-consuming for patients. It is costly to the NHS, with figures in 2006 from a multi-centred study based in the UK, quoting a median cost of €6075.25 (Kumar et al., 2006b). It is likely that some AOB patients will have had a NNSH, which would have been suitable for interceptive management, allowing cessation of the habit, and reduction or even elimination of the resulting malocclusion. This could be of significant benefit to patients, with less extensive treatment required, or even eliminating the need for treatment.

The systematic review presented in Chapter 3, regarding interventions for the cessation of NNSH, has highlighted providing thumb sucking patients with a fixed palatal crib can be 100% effective if left *in situ* for 10 months (Haryett et al., 1967). However, it is acknowledged that there was no long-term follow-up of this group of patients to know whether there was any recurrence of the habit. Another study included in the review looked at providing a fixed habit breaker for thumb suckers, and demonstrated a mean reduction in anterior open bite (AOB) of 3.7mm (SD 1.9) (Villa, 1997) following cessation of the habit. The patients ranged from eight to eighteen years of age, and it may be that the reduction in AOB would have been greater if the age range had been narrower, treating patients when they still had

significant growth potential, allowing for spontaneous correction of the malocclusion.

In the UK, orthodontic treatment need is routinely assessed using the Index of Orthodontic Treatment Need (IOTN), with patients being eligible for NHS funded treatment if they have a dental health component of at least Grade 3 or above (a moderate need for treatment), in conjunction with an aesthetic score of six or above. With limited resources available, it is important that these are targeted appropriately, and therefore it is worth considering intercepting simple occlusal anomalies in the mixed dentition, to reduce treatment need and the requirement for orthodontic treatment. A recent economic study looked at the care of patients in the USA, and the best use of resources, with respect to Medicaid (Bresnahan et al., 2010). The authors conducted a systematic review of the relevant economic literature, and identified issues from the perspectives of the various stakeholders (dentists, patients and parents, Medicaid programs). They developed a conceptual model for studying decision-making, focused on the strategy of providing early interceptive and preventive treatment rather than, or in addition to, comprehensive care in the patient's permanent dentition. They concluded that policymakers, and the dental community, should try to identify solutions to address low-income families' limited access to orthodontic services. These should be examined, from various perspectives, with regard to their relative cost-effectiveness. Research in this subject (Jolley et al., 2010, King and Brudvik, 2010, King et al., 2006, Mirabelli et al., 2005) has suggested that providing a basic level of interceptive orthodontic treatment to many patients is a better use of resources, than providing complex treatment to fewer patients. The authors accept that interceptive orthodontics did not produce “finished results,” but reduced the treatment need from “medically necessary” to elective. At a time when health care resources are limited by total funds available, as well as through competition with other areas, it is important to ensure that these resources are being utilised effectively.

If the approach described above was adopted in Scotland, there would be potential cost savings to be made within the NHS, providing simple interceptive treatment rather than comprehensive treatment at a later date. The focus of this study therefore, is to determine the size of this potential cost. The cost to NHS Tayside, for the provision of interceptive treatment for cessation of thumb sucking will be

calculated, and where treatment would not have been successful (or not provided), the costs of correction of the associated malocclusion will be calculated.

## **7.2 Literature Review**

### **7.2.1 Introduction**

Over a decade ago the need for cost effectiveness was featuring in orthodontic journals discussing the need to appropriately allocate resources, and targeting high need patients. Richmond discussed the need to deliver a high standard of care at the lowest cost, and the possible use of the peer assessment rating (PAR) index to facilitate this, along with its associated disadvantages. Richmond (2000) mentioned the need to take into consideration all costs, such as indirect costs, including loss of earnings, and intangible costs such as pain. Cunningham (2001) introduced the readers of her article to the different methods of economic evaluation, what they involved, and stressed the importance of understanding them when designing a service which produces the best health care for patients using the resources available.

With the ever increasing demands on the NHS, cost analyses have continued to play an important role, ensuring resources are targeted appropriately and that value for money is achieved. There are different types of cost analysis, and the appropriateness will depend upon the purpose of the assessment, and the availability of data and other resources. Listed below are the most common types of analyses and an explanation about each one.

#### *Cost-effectiveness analysis (CEA)*

The consequences of interventions or decisions are measured in the most appropriate natural effects or physical units, such as symptom-free days, heart attacks avoided, deaths avoided or life years gained (that is, the number of years by which life is extended as a result of the intervention). No attempt is made to value the consequences in monetary terms, so in some ways these studies implicitly assume that the output concerned is “worth having.” The results of a cost-effectiveness study are expressed in the form of a cost-effectiveness ratio.

### *Cost-consequence analysis (CCA)*

This method of appraisal is a variant of a cost-effectiveness analysis, and typically involves presenting the array of outcomes in their natural units (some of which may be monetary) alongside their costs. It is then left to decision-makers to determine whether overall, the treatment is worth carrying out.

### *Cost-utility analysis (CUA)*

The benefits/consequences of interventions are adjusted by health state preference scores or utility weights, and so states of health associated with the outcome measure are valued relative to one another. The result is that the quality of (for example) life-years gained can be assessed as well as the crude number of years gained. The most common outcome measure in cost utility analyses is the quality-adjusted life year (QALY).

### *Cost-benefit analysis (CBA)*

In this method of evaluation, the consequences of a decision, programme or project (over a certain period), and those of its alternatives (within the same period), are valued in monetary terms to ascertain whether the benefits justify the costs. In theory, this is the broadest form of evaluation; however, difficulties often arise when trying to value benefits in money terms. A number of approaches can be adopted to assign a monetary valuation to health outcomes; human capital, revealed preferences, and stated preferences of willingness to pay.

### *Cost-minimisation analysis (CMA)*

This type of analysis should only be used in situations where the benefits of alternative treatments have been proven to be identical. It is therefore frequently employed to support and justify the introduction of cheaper drugs. In cost-minimisation analysis, the least expensive option is preferred.

The methods of economic evaluation outlined above can be referred to as full evaluations as they meet the following criteria (Kumar et al., 2006a): there is a comparison of two or more alternatives; cost data are assessed; consequence/outcome data are assessed. Health care evaluations do not always need to fulfil all three criteria. Drummond et al. (2005) also describe *cost analysis* as a



method of evaluation. This represents a modification to the above criteria, and gives a partial economic appraisal which deals only with costs. Partial evaluations can help in the understanding of individual aspects of the costs and consequences of health services, and may be appropriate when the study is concerned with one specific viewpoint.

This literature review will explore cost analyses which have been conducted over the last ten years relating to orthodontics, whether in conjunction with other treatment, or orthodontic treatment only.

### **7.2.2 Orthognathic cost analyses**

Over the past decade, cost related research in the field of orthognathic surgery has been conducted by a number of authors (Cunningham and Hunt, 2000, Panula et al., 2002, Cunningham et al., 2003, Van Strijen et al., 2003, Kumar et al., 2006b, Kumar et al., 2008, Farrell and Tucker, 2009,). Summaries of the studies are presented in Table 7.1. It can be seen that there have been a variety of analyses used, the simplest being a detailed costing. It is interesting to note that the UK studies concluded that orthognathic surgery generated good value for money from NHS resources (Cunningham et al., 2003). In Finland however, surgical-orthodontic treatment was deemed a rather expensive way of correcting dentofacial malocclusions, due to the high cost of the surgical phase of treatment (Panula et al., 2002). Exploring the percentage of the overall cost for the surgical phase (inpatient costs and theatre costs), the UK study calculated this to be approximately 57% (Kumar et al., 2006b), and the Finnish study approximately 61%. It is curious that this 4% difference has resulted in opposite conclusions being drawn

**Table 7.1;** Cost analysis studies relating to orthognathic surgery.

<b>Study</b>	<b>Cost Analysis</b>	<b>Method</b>	<b>Findings</b>	<b>Limitations of study</b>	<b>Conclusions</b>
Cunningham and Hunt, 2000	Cost utility analysis	Control group and an experimental group (had dentofacial deformity). 3 methods were used to establish utility values for pre-treatment dentofacial appearance; rating scale, standard gamble and, time trade off.	There were no significant differences between the mean utility values for the two study groups for any of the three methods.	This study is only the first part in the cost utility analysis; obtaining the utility values for pre-treatment patients about to undergo combined orthodontic orthognathic surgery.	SG and TTO had greater repeatability than the RS. The methods used were acceptable to participants and the groups understood the hypothetical situations.
Cunningham et al., 2003	Cost utility analysis	21 patients were interviewed 5 times during treatment to establish utility values and calculating quality	Each QALY had an incremental cost of £561, making orthognathic surgery a procedure that provides a good outcome	Small sample size and no control group, sample of patients from a teaching hospital and not a district general and the	Orthognathic treatment produced improvements in the quality of life, highly valued by patients, and

		adjusted life years (QALYs) following treatment. The costs acquired during treatment for each individual patient were calculated.	at a relatively low cost	fact that the immediate post-surgical care does not occur in an intensive care or high dependency unit potentially having a large effect on the cost of treatment.	generated good value for money from NHS resources.
Farrell and Tucker, 2009	Descriptive analysis	Explored means to obtain maximum insurance coverage, reduce costs in the hospital environment and use outpatient surgical treatment services.		No formal cost analysis is performed. United States based, with very different provision of health care to the UK.	To make surgery more affordable and accessible, the authors recommend performing orthognathic surgery in the outpatient setting.
Kumar et al., 2006b	Cost description analysis	Calculated the direct health service costs relating to orthognathic surgery in the UK.	The average total cost for treatment was €6293.72*, with an average orthodontic treatment cost	Retrospective and very reliant on the accuracy of the patient records, however the authors	Orthodontic treatment to facilitate orthognathic surgery in the NHS is

		Due to the variation of individual operators, 20 hospital records were analysed to establish an average of consumables per patient.	of €1496.79 per patient. Treatment costs for patients with a Class III malocclusion were significantly higher than those with a Class II malocclusion, and that patients with an AOB were significantly higher than those with an increased overbite. On average 43% of the total treatment cost was due to outpatient costs 22% was in-patient costs and 35% theatre costs.	recognise that a prospective design would be labour intensive and costly.	inexpensive.
Kumar et al., 2008	cost description analysis	Calculated the direct NHS costs relating to the surgical aspects of orthognathic surgery	Inpatient costs, on average per patient were €1299.31* and the average operating theatre costs was	Retrospective and very reliant on the accuracy of patient records.	This study added further information to the previous one with respect to the surgical costing of orthognathic

		Costs were calculated for operating theatres, ward stay, theatre consumables, consumables (e.g radiographs), staff costs, capital and overhead costs.	€2189.54.  The staff capital and overheads accounted for 44% of the total theatre cost. There was variation in cost across hospital units, giving a range of total treatment cost from €5312.26 to €7798.50.		treatment.
Panula et al., 2002	Cost description analysis	The treatment process was divided into 4 phases; pre and postoperative orthodontics (up to removal of fixed appliances and beginning of retention), treatment at the OMFS outpatient clinic, the	Average cost for combined treatment was \$6206 ± \$912*.  Orthodontic treatment accounted for an average of 39% of the total cost, followed by the surgical operation, 28% of the total cost. 19% of the cost was OMFS outpatient clinic	Retrospective and very reliant on the accuracy of patient records.	Authors concluded that combined treatment is a rather expensive way to correct dentofacial malocclusions due to the high costs of the surgical phases, which constitute roughly 61% of the costs, 28% of which are due to the

		operation, and inpatient stay.	and 14% was the inpatient stay.		surgical operation itself.
Van Strijen et al., 2003	Cost comparison analysis	Compared the cost, operation and hospitalisation times of distraction osteogenesis versus sagittal split osteotomy in the Netherlands in patients with Class II skeletal patterns. Costs were calculated for the surgical materials, operation and hospitalisation.	The total cost average cost for a patient receiving distraction treatment was €3776* and for a BSSO was €2448, with the difference being largely attributable to the cost of the distractors.	Little information given regarding the clinical decision to provide the different treatments, or the range of severity of skeletal discrepancies. An RCT would address these issues but would take several years to complete.	Discussion of the potential benefits of distraction despite its increased cost, less likely permanent damage to the inferior alveolar nerve and less lengthy orthodontic treatment. Authors suggest consideration to the sterilisation and reuse of distractors.

\* In these studies, the costs were presented in Euros, not Pounds Sterling.

### 7.2.3 Cost analyses of cleft care and pre-surgical orthopaedics

Konst et al. (2004) conducted a randomised controlled trial in three centres, comparing the cost effectiveness of infant orthopaedic treatment (IOT), versus no treatment, in children with complete unilateral cleft lip and palate, focusing on the effects on speech development at age 2 ½ years of age. At aged 2 ½ years all participants had spontaneous speech samples recorded, and these were evaluated by five trained listeners. The mean cost for a patient in the IOT group was €1,460, and €419 for the non IOT group. The incremental cost effectiveness for IOT, compared with non IOT, was €1,041 for 1.34 point speech quality improvement, or €777 per point speech quality improvement. The authors concluded that from a speech development perspective, the cost effectiveness of providing infant orthopaedic treatment was acceptable. It is difficult to draw meaningful conclusions from this paper other than providing IOT improves speech. It may have been worth considering converting speech quality improvement to QALYs. If the results had been produced using QALYs, comparisons with other studies which used QALYs could have been made, appreciating the cost effectiveness of this treatment.

Pfeifer et al. (2002) compared the financial impact of two treatment approaches to unilateral cleft alveolus; nasoalveolar moulding (NAM) plus gingivoperiosteoplasty (GPP) at the time of lip repair (n=16), compared with the traditional approach of secondary alveolar bone graft (n= 14)(control group). An average cost of \$19,745 of treatment for the NAM, GPP, and primary nasal repair was calculated, and for the control group the cost was \$22,744. However, in the NAM plus GPP group, six patients required a further alveolar bone graft, i.e. six patients had both treatments. The authors concluded a cost saving could be made in the management of unilateral cleft alveolus using NAM and GPP at the time of lip repair. However, the effect of GPP on maxillary growth would need to be reviewed, by examining how many patients subsequently require a Le Fort 1 maxillary advancement later in life. Also, the number of nasal revisions required in the NAM plus GPP group will be reviewed. The authors recognize the need to re-examine the cost effectiveness, when this data is available.

The conclusion drawn by the authors appears to be unsubstantiated, as nearly 38% of the sample who received NAM and GPP also required conventional surgery. It

would appear that this analysis has compared two treatments which do not have the same effect, particularly as the authors are unsure of the long term effect on maxillary growth a need for orthognathic surgery using the GPP technique.

#### **7.2.4 Cost analyses relating to oral appliances and snoring**

Main et al. (2009) performed a systematic review of clinical effect and associated treatment costs of managing non apnoeic snoring, with surgical procedures or non-surgical devices. The review included 27 studies, with various surgical techniques described, and non-surgical treatment options of continuous positive airway pressure (CPAP) devices, and mandibular advancement (MA) splints. The studies had small samples and were of poor quality leading to cautious conclusions, but there was no obvious difference in cost. The authors recommended the need for standardised measuring outcomes and reporting, with investigation into the longer term effect of the treatments. These conclusions highlight again some of the issues already mentioned, relating to equal effects of different treatments, and long term implications and associated costs.

Sadatsafavi et al. (2009) looked at the cost effectiveness of oral appliances in the treatment of obstructive sleep apnoea. They compared oral appliances (OA) with CPAP devices, and the primary outcome was the incremental cost effectiveness ratio (ICER) in terms of cost per one quality life adjusted year (QALY) gained 5 years after treatment. The results showed compared with no treatment, OA resulted in an ICER of \$2,984 per QALY, compared with no treatment CPAP resulted in an ICER of \$13,698 and compared with OA, CPAP resulted in an ICER of \$27, 540 per QALY. In the USA it is currently recommended that treatments which result in <\$50,000 per one additional QALY be adopted. Therefore, both treatments were regarded as highly favourable. The limitations of the study, as identified by the authors, were;

- the use of assumptions regarding the effect of OA due to the lack of evidence,
- the assumption of equal adherence to CPAP and OA,
- the restriction of the study population to those with moderate to severe obstructive apnoea hypopnoea, and,
- the potential differences in cost of the various types of OA.



The assumptions of equal adherence to both treatments and effect of OA could have considerable influence on the results, and they should be viewed with caution. It would have been worth considering a sensitivity analysis, varying the adherence to treatment and effect of OA, and presenting these results alongside the findings.

#### **7.2.5 Cost analysis studies relating to orthodontic only treatments**

Richmond et al. (2004, 2005), Deans et al. (2005), Hichens et al. (2007), Petré (2011), and Richmond and Karki (2012) have all recently investigated costs relating to orthodontic treatment, in particular the cost effectiveness of treatment. Summaries of the studies are shown in Table 7.2.

**Table 7.2;** Cost analysis studies relating to orthodontic treatment.

Study	Cost Analysis	Method	Findings	Limitations of study	Conclusions
Richmond et al., 2004	Cost effectiveness analysis	Used the Index of Complexity, Outcome and Need (ICON), and calculated cost of treatment. Costs were categorised into direct costs, patient costs & service costs. Proportion of acceptable outcomes of cases treated, who actually needed treatment, was analysed. The expected costs per successful outcome per practitioner were obtained.	The cost per ICON point reduction for the three practitioners was calculated. Also, costs relating to initial need for treatment, and outcome were obtained.	Used ICON for recording pre and post treatment results, not an index commonly used in the UK. No mention of who scored the occlusions pre and post treatment.	The authors stress the importance of cost effectiveness in decision making, and that it can be used by practitioners to rank their own performance against others.

Richmond et al., 2005	Cost effectiveness analysis	Prospective study with orthodontists from hospital, community and practice, submitting information on cost of treatment by completing questionnaires. Patients also completed questionnaires.	The most cost effective service was provided by clinicians working in community settings.	ICON was used to score the malocclusion pre and post treatment, with no mention of who did this. Reliant on responses in questionnaire being accurate	The costs and effectiveness of the clinicians in each setting showed considerable variation.
Deans et al., 2009	Cost effectiveness	10 specialists in seven countries were examined, and data was collected retrospectively for consecutively treated patients. Direct treatment costs were used as the fee received by the orthodontists. Cost effectiveness was calculated as the cost per	The total number of treated cases ranged from 14 to 50, with a range in treatment costs of €335.90 to €2002.70. It was found that the median cost per ICON point reduction for all the cases in this study (429) was €57.70.	The authors recognise that due to the retrospective nature of this study there was the possibility of orthodontists submitting their best cases for scoring. Who carried out the ICON scoring?	ICON point reduction offers a method to calculate the cost effectiveness of treatment which can be compared with other practitioners.

		ICON point reduction for each orthodontist.			
Hichens et al., 2007	Cost effectiveness	<p>The cost effectiveness was studied from the perspectives of the NHS, orthodontic practice and the patient.</p> <p>Costs to the NHS were calculated using the SDR. Costs to the practice was calculated by working the total time spent on retainer appointments over 6 months, for both retainer groups, multiplied by the gross clinical time cost per minute.</p> <p>Costs to the patient were</p>	<p>The mean cost to the NHS per subject was €152.42 for the Hawley group and €121.08 for the VFR group. The profit to the practice was €1.22 for the Hawley group and €33.83 for the VFR group.</p> <p>62 patients had to attend extra appointments; 41 Hawley and 21 VFR.</p> <p>The costs to the patients were €9.15 for the Hawley group and €6.93 for the VFR group.</p>	Patients were only followed up for six months and retention regimes are usually for longer than this.	VFRs were more cost effective than Hawley retainers (over 6 months of retention) from the perspective of the NHS, the orthodontic practice and the patient.

		calculated on those incurred by the patient, and their parent/carer, for attending unscheduled appointments during the 6 month trial period.			
Petrén, 2011	Cost minimisation analysis (Quad helix versus URA)	Using the data from their previous work, 40 subjects in the mixed dentition, with treatment for unilateral posterior crossbite, duration of Tx, number of appointments, broken appointments, and cancellations were collected. Direct costs and indirect costs were calculated and evaluated for successful Tx alone, for successful &	The results showed that the QH had significantly lower direct and indirect costs, with fewer failures requiring re-treatment.	Well conducted study	In terms of cost-minimization the quad helix is the ideal choice of appliance when correcting a posterior crossbite in the mixed dentition.

		unsuccessful treatment, and re-treatment when required.			
Richmond and Karki, 2012	Cost efficiency analysis	<p>Orthodontic treatment need and uptake was estimated for a population of 12-17 years olds in Wales. Orthodontic data from 2008/2009 regarding contracted services was analysed.</p> <p>Data was available of the relative costs of orthodontics in the GDS/PDS. The relative costs in the HDS and CDS was obtained using a questionnaire.</p>	<p>The average estimated cost for treatment in the hospital dental service (HDS) was £2120 compared with £1609 in the community dental service (CDS). The cost was also calculated for combined general dental service, and personal dental service and ranged from £1364 to £1628</p>	<p>The authors recognise the limitations of this study; the data collected from the HDS and CDS were self-reported and relative cost efficiencies were based on questionnaires and some assumptions. The complexity of cases and level of training varied between the salaried services.</p>	<p>The average cost for treatment in the HDS is always going to be higher due to the nature of the cases treated and that there are often trainees treating patients. This should be borne in mind when comparing the costs of treatment across settings.</p>

From these summaries it can be seen that cost effectiveness analyses (CEA) were most commonly performed. There was one minimisation analysis, and this was carried out to a high standard. With regard to the CEA, the work by both Deans (2005) and Richmond et al. (2004, 2005) uses ICON to score the malocclusion, pre and post treatment. There is no mention of who performed the scoring, and this may have introduced significant bias if there was no blinding. One of the studies used questionnaire data to identify costs (Richmond and Karki, 2012), this again will have introduced inaccuracies.

### **7.2.6 Summary of the literature**

Like all areas of research, when performing a cost analysis the type of study design depends on the research question to be answered. It is easy to introduce bias and make assumptions which lower the quality of the study, impacting on the validity of the conclusion. From the literature it can be seen that the main type of cost analysis performed has been a cost effectiveness analysis. However, for this to be successful, evidence needs to be available regarding the success of the treatment being analysed, and for all the costs encountered. Where this is not possible, a cost description analysis gives a transparent and descriptive overview of the costs. It can be seen that it is not always possible to obtain detailed costings for all aspects of treatment, and estimates have to be made. Where any estimated figures have been used, either with costings or treatment success, a sensitivity analysis is performed.

## **7.3 Cost analysis study for thumb sucking habits**

### **7.3.1 Aim**

The approach that has been adopted in this analysis is a descriptive cost analysis, as it is not simply comparing different treatments to stop thumb sucking, but also considers the costs of treatment associated with any resulting malocclusion. The perspective of the analysis is also an important factor in any economic evaluation. This study proposes there is a potential cost saving to be made for the NHS, and so the analysis focuses only on the costs to NHS Tayside. Although not being considered here, it is important to note that there are wider social costs associated

with the treatments being discussed, and a full economic evaluation would take these into account.

Essentially, this study compares the cost of the various treatment options which are currently available within NHS Scotland for treating and managing the problem of thumb sucking. It looks at providing either an upper removable appliance or fixed habit breaker appliance to stop the habit, and potentially stop the malocclusion from developing/worsening. The alternative, of allowing the malocclusion to develop and subsequently correcting it with fixed orthodontic appliances, and if necessary combined orthodontic and orthognathic treatment, is explored.

## **7.4 Materials and Methods**

### **7.4.1 Treatment Pathways**

There is a range of possible treatment pathways which a patient may follow, depending upon the success of initial treatments. The cost analysis was determined by considering the treatment scenarios for a nine year old, presenting at a routine appointment, with an AOB and a thumb sucking habit. The possible interceptive treatment options leading to cessation of the habit and potential resolution of the AOB are listed below. It is assumed that all scenarios begin with psychological advice and a recommendation to try applying paint to the thumb by the GDP. Capitation fees a dentist would receive, regardless of the treatment are also excluded from the analysis.

#### **Scenario 1 – No interceptive Treatment**

**1a** Treatment start date - January 2011. At a routine appointment the habit is detected, advice is given and paint is recommended. At a routine appointment in January 2012, the decision is made to monitor the patient until the child is 14 years of age. By this time the habit has stopped, the problem has corrected, or minor malocclusion is accepted, and no further treatment is required. Treatment end date is January 2016.

**1b** Treatment start date - January 2011. It is the same as pathway 1a, but after the monitoring stage, simple orthodontic treatment is required (upper and lower fixed



appliances). Treatment starts January 2016, braces removed July 2017, and following a period of reviewed retention the treatment ends April 2019.

**1c** Treatment start date - January 2011. It is the same as pathway 1a, but after the monitoring stage, the problem is more severe, and a combination of orthodontic treatment and surgery is required. Brace treatment is delayed two years until the patient is 16 years of age (January 2018), surgery conducted in July 2019, braces removed in July 2020, followed by a period of retention. Treatment ends April 2022.

### **Scenario 2 – Upper Removal Appliance**

**2a** Routine appointment in January 2011, advice given and paint recommended. The patient is reviewed in January 2012 and the habit/problem remains. The decision to use an upper removable appliance is made. This is used for six to nine months, is successful, and the treatment ends between July and October 2012.

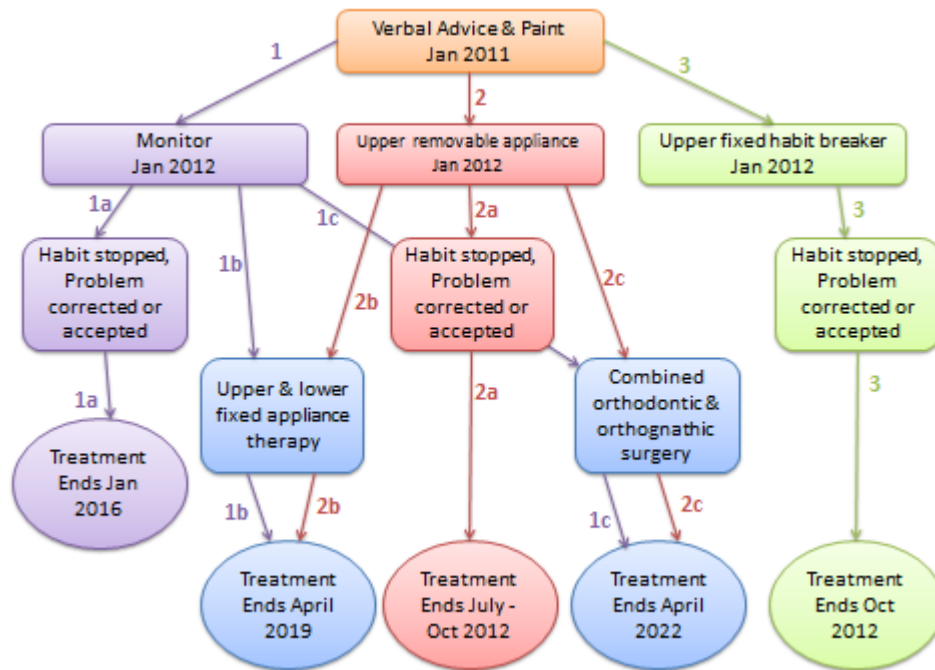
**2b** This is the same as pathway 2a, however the URA is not successful, and simple orthodontic treatment is required (upper and lower fixed appliances). The patient follows the same pathway as scenario 1b – treatment starts in January 2016, ends April 2019.

**2c** This is the same as pathway 2b, however the malocclusion is more severe, and the patient follows the pathway as for scenario 1c, treatment starts in Jan 2018, ends April 2022.

### **Scenario 3 – Fixed Habit Breaker**

Routine appointment in January 2011, advice given and paint recommended. The patient is reviewed in January 2012 and the problem/habit remains. The decision to fit a fixed habit breaker (FHB) is made. The appliance is removed after ten months, has successfully stopped the habit, and no further treatment is needed.

The costs associated with all possible treatment pathways the patient could follow were calculated. The costs calculated for the pathways presented in Figure 7.1 are representative of a single patient following the possible different scenario-based treatment pathways. The second part of the study considered the actual cost of providing this treatment in NHS Tayside, and the potential cost savings in Tayside if there was a change in clinical practice.



**Figure 7.1;** Treatment pathways for a nine year old with a thumb sucking habit.

#### 7.4.2 Identification of costs

This evaluation is being conducted from the viewpoint of the NHS, therefore only direct health service costs were considered. The treatment options described are conducted in both the primary and secondary care settings. In Scotland, the fee-per-item of service system is used, therefore the fees dictated in the Statement of Dental Remunerations (SDR) 2009-2010 have been used for treatment carried out in general practice, or by a primary care orthodontist. These fees are designed to cover the cost of the treatment, staff time, patient assessment, study models and appliance costs. Where treatment is provided in the secondary care setting, the costs were calculated for staff, materials, sterilisation of instruments, consumables, and radiographs.

The treatment pathways illustrated in Figure 7.1 consist of the interceptive options outlined above, upper and lower fixed appliance therapy, or combined orthodontic orthognathic treatment. The provision of upper and lower fixed appliances could be carried out by primary or secondary care orthodontists (hospital consultants), therefore both costs were calculated. In the hospital setting, costs include;

- upper and lower fixed appliances for an average treatment time of 18 months,
- nursing and technician support,
- materials and chair side time,
- costs of sterilisation of instruments,
- taking of radiographs,
- cost of upper and lower vacuumed-formed retainers, together with three retainer review appointments.

In the hospital setting, average salary scales were used for nurses, technicians, and consultants to calculate an hourly rate. Costs were produced for orthodontic materials, sterilisation of instruments and consumables. Figures were available for the average cost of a radiograph in Dundee Dental Hospital, from the Information Services Division (ISD) Scotland (April 2010 to March 2011; released November 2011), and these were used. ISD is an authoritative source of Scottish national healthcare statistics providing health service data costs.

The cost for orthodontic materials was calculated at an average of 24 brackets, four bands, and eight arch wires. With regard to the orthodontic treatment costs for a specialist in practice, the SDR fees were used. For combined orthodontic orthognathic care, the orthodontic treatment cost was based on provision of treatment by a Consultant Orthodontist. This also included the cost of three appointments at a combined clinic, with Consultant Orthodontist and Consultant Oral and Maxillofacial Surgeon (an hourly rate is calculated for the surgeon, to account for joint consultation clinic appointments). Additional technician time as included to allow for construction of surgical wafers, theatre costs, and a three night stay in hospital. Also, the cost of a further six months of orthodontic appointments was calculated, as combined treatment takes longer. The further cost of crimpable hooks and additional radiographs were included. Once again the cost of retainers and three retainer review appointments are included for this treatment.

Using ISD, costs were available for the average maxillofacial operation in Ninewells Hospital, Dundee. These costs include all direct costs; staffing, pharmacy, AHP (allied health professionals, such as dieticians) theatre costs and medical laboratory costs (for blood tests etc), as well as allocated costs, giving a gross cost per case. It is acknowledged that these orthognathic cases may be bi-maxillary or maxilla only, but there was no available data for separate costs, only a combined average cost which was therefore used in this study. The costs associated with each treatment option are displayed in Table 7.3.

**Table 7.3;** Costs of treatment options for managing a persistent thumb sucking habit.

Pathway	Interceptive Treatment	Cost to NHS, in £		What is included in the cost
<b>1bi</b>	No interceptive treatment provided, orthodontic treatment by Primary care orthodontist	exam	25.05	Course of upper and lower fixed appliance and upper and lower removable retainers, review period of retention, radiographs (2 lateral cephalograms and 1 OPT), study models, and examination.  All as per the SDR.
		U/LFAs	676.72	
		models	17.77	
		retention	45.89	
		retainers	96.70	
		x rays	48.56	
		Total	910.69	
<b>1bii</b>	No interceptive treatment provided, orthodontic treatment by Consultant orthodontist	staff cost	406.40	Staffing costs included 7 hours of chairside time for both consultant and nurse and one hour technician time**. Course of upper and lower fixed appliance and upper and lower removable retainers, including consumables, sterilization of instruments, 2 lateral cephalograms and 1 OPT.
		materials	152.00	
		ster & cons	273.06	
		x rays	82.38	
		Total	913.84	
<b>1c</b>	No interceptive treatment provided, orthodontic Tx and	staff cost	696.20	Staffing costs included 9.5 hours of chairside time for both consultant and nurse***, 3 joint clinic appointments with OMFS
		materials	227.82	

	orthognathic surgery in hospital setting	ster & cons 394.42 x rays 109.84 surgery 5068.00 Total 6496.28	consultant, 4 hours of technician time for surgical wafer & retainers. Materials for fixed appliances, disposables & sterilization of instruments, hospital operation including 3 nights stay, 3 lateral cephalograms and 1 OPT.
<b>2a</b>	Interceptive treatment - URA by GDP or Primary care orthodontist	25.05 17.74 8.77 120.65 Total 172.21	Full assessment, study models and working model, fee for URA as per the SDR.
<b>2b</b>	URA unsuccessful therefore orthodontic Tx in secondary care	172.21 plus 913.84 Total 1086.05	
<b>2c</b>	URA unsuccessful, requires combined orthodontic orthognathic Tx	172.21 plus 6496.28	

		Total	6658.49	
<b>3i</b>	Interceptive treatment – fixed habit breaker provided by GDP or Primary care orthodontist	25.05 17.74 8.77 115.69  Total	167.25	Full assessment, study models and working model, fee for fixed appliance as per the SDR.
<b>3ii</b>	Interceptive treatment – fixed habit breaker provided by hospital Consultant.	staff cost 174.57 materials 8.00 ster & cons 91.02  Total	273.59	Staffing costs included 2 hours 50 minutes of chairside time for both Consultant and nurse, and 1 hour technician time*. Costs for sterilisation of instruments and consumables calculated.

i Primary care setting,    ii Secondary care setting

\* Two hours fifty minutes was arrived by adding the times for;

- 30 minute assessment,
- 20 minutes each for separators, band placement and impression taking, and fitting of appliance (60 minutes in total),
- two 20 minute review appointments (40 minutes),
- 20 minute debond appointment, and,
- 20 minute post treatment review.

\*Seven hours was arrived at by adding the times for;

- 30 minute assessment appointment,
- 30 minute treatment plan appointment,
- 40 minute bonding appointment,
- ten 20 minute adjustment appointments (200 minutes),
- 40 minute debond appointment,
- 20 minute fit vacuum formed retainers (VFRs), and,
- three 20 minute review retainers appointments (60 minutes).

\*\*Ten and a half hours was arrived by adding the times for;

- 30 minute assessment appointment,
- 20 minute joint clinic appointment,
- 40 minute bonding appointment,
- ten 20 minute adjustment appointments (200 minutes),
- 20 minute facebow record/check occlusion with surgeon,
- 20 minute try wafers,
- nine 20 minute post-operative adjustment appointments (180 minutes),
- 40 minute debond,
- 20 minute fit VFRs appointments, and,
- three 20 minute review retainer appointments (60 minutes).



### 7.4.3 Discounting

Discounting is a technique used in economic appraisal to take into account the differential timing of costs and/or benefits. Costs and benefits usually occur at different points in time, and quite often costs occur today, and the benefits accrue sometime in the future. In order to allow for this time difference, the basic economic principal of discounting is used. Discounting scales down future costs and benefits, to reflect the general preference for enjoying benefits sooner rather than later, and incurring costs in the future rather than today. It is used to make streams of benefits and costs comparable for the purposes of appraisal.

Although the need to discount costs to a present value is widely accepted in economic evaluation, the specific rate which is applied is variable across jurisdictions and over time periods. The National Institute for Health and Clinical Excellence (NICE) has published guidance on the methods of technology appraisal (NICE, 2008). This guidance states an annual rate of 3.5%, which is based in the recommendation of the UK Treasury (HM Treasury, 2003) for the discounting of costs, should be applied. The guideline further recommends that when results are potentially sensitive to the discount rate used, consideration should be given to sensitivity analyses which use differential rates for costs and outcomes, and/or vary the rate between 0% and 6%.

This study was concerned only with costs, so it is not necessary to consider the differential timing between when the costs were incurred and the benefits accrued. However, much of the orthodontic treatment discussed in this analysis occurs at some point in the future. Patients would not receive orthodontic treatment until the age of 12 to 14, and the orthognathic surgery would not be occurring until patients were possibly 18 to 19 years of age. All costs used in the analysis are based on 2011 prices, and have been discounted at an annual rate of 3.5% to reflect the fact they are occurring in the future. To account for inflation no costs have been inflated, and the real discount rate of 3.5 % was used.

The following formula was used to discount costs:

$$P = \sum_{n=1}^n F_n(1 + r)^{-n}$$

Where  $P$  = Present Value,  $F_n$  = Future cost at year  $n$ , and  $r$  is the annual discount rate. The discounted costs are shown in the results tables 7.4 and 7.5.

#### **7.4.4 Effectiveness of interventions**

The second part of the analysis used evidence from the literature to populate the scenarios described in Figure 7.1, with a view to calculating the actual orthodontic costs associated with managing the problem of thumb sucking in Tayside.

From the available data, 12% of children in the UK have a prolonged digit sucking habit past the age of seven years (Patel et al., 2008). It has also been reported that signs of digit sucking are seen in 12% of nine year olds (Larsson, 1972), and 61% of children ten year of age with a persistent habit having a co-existing malocclusion (Popovich, 1966). In a recent study a group of seven to thirteen year of age who were thumb suckers or had given up less than two years previously, AOBs were present in 36% of the sample, compared to none in a control sample (Mistry et al., 2010). Therefore, we estimated for the purpose of this study, approximately 4% (4.32%) of nine to ten year olds have an AOB that is due to a NNSH (36% of 12%). Sixty two per cent of eight year olds, and 63% of 12 year olds, are reported to attend a GDP regularly (Morris et al., 2006), hence the figure of 62% of nine and ten year olds attending a GDP was used for calculations.

Applying 'paint' to a child's thumb to stop the digit sucking habit is only effective in 10% of cases (Azrin et al., 1980). The success of psychological techniques provided by the GDP, to be used by the patients' parent/carer, to persuade the child to stop sucking their thumb was set at 30%. This was estimated from published reports of success of various psychological techniques ranging from 9% to 53% (Haryett et al., 1967, Larsson, 1972, Azrin et al., 1980, Christensen and Sanders, 1987). However, it is not known how often these specific techniques are used, and it is assumed that patients and parents may only receive verbal advice rather than instruction on

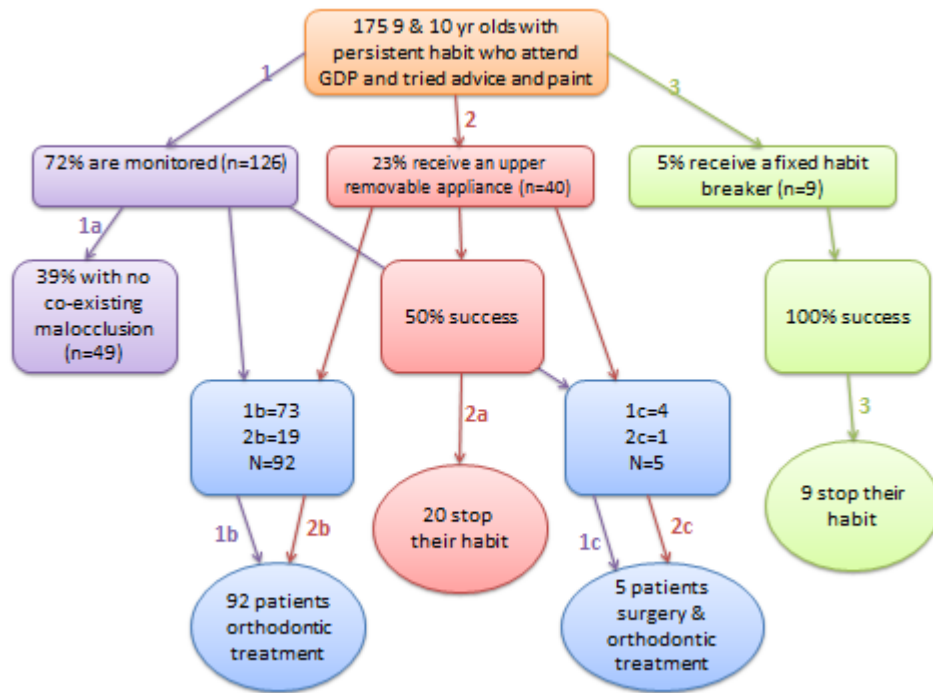
specific techniques. Therefore, it was decided to set the level of success of combined paint and or psychology/advice, from parents and GDP, at 20%.

Of the 80% of patients in which this is ineffective, there is no data to determine how many will then try a URA, a fixed habit breaker, or remain to be monitored.

However, the data from the questionnaire in Chapter 6 showed 23% of GDPs would provide a URA in this situation. The use of a URA has been estimated as being effective in 50% of cases (Litt and Cuskey, 1980, Bartsch et al., 1993, Schott and Göz, 2010). For the remaining 50% of patients where this is not effective, they would subsequently require fixed appliances, or possibly even orthodontic and orthognathic treatment.

The use of a fixed habit breaker has been reported as effective in 100% of cases (Haryett et al., 1967). There is no available evidence to demonstrate how often a fixed habit breaker is used, but it is known to be low, and estimated for this analysis at 5%. With regard to the group of patients who are monitored only, using the data of 61% of ten year olds with a persistent habit having a co-existing malocclusion (Popovich, 1966), this would give some indication of how many patients will require treatment.

From national statistics (General Register Office for Scotland, 2011), there were 8161 nine and ten year olds in Tayside in 2010. Assuming that 4.32% of them have an AOB, this equates to 353 patients. If only 62% regularly attend their GDP, there are approximately 219 who are amenable to treatment. If they all receive some verbal advice or apply 'paint', some 20% will have success, leaving 175 with a persistent habit who will follow one of the three arms of the flow diagram. For those who are either monitored or who have a URA, but fail to stop their habit and develop a malocclusion requiring treatment, it is assumed that the majority would be treated with orthodontic appliances alone (95%), and 5% treated by a combined orthodontic orthognathic approach. This information was used with the pathways outlined in Figure 7.1 to estimate the cost in Tayside of managing AOBs due to thumb sucking (Figure 7.2 and Table 7.4).



**Figure 7.2;** NHS Tayside Example.

**Table 7.4;** Current cost to NHS Tayside, for thumb sucking patients.

Patient Pathway	NHS cost in primary care (where possible)	NHS cost solely in secondary care
1a	£0	
1b	£66,445	£66,675
1c	£24,946	
2a	£3,463	
2b	£20,688	£20,748
2c	£6,705	
3	£1,462	£2,392
Total cost	£123,710	£124,930
Discounted cost	£96,914	£98,033

#### **7.4.5 Sensitivity analysis**

There may be considerable uncertainty about predicted impacts and their appropriate monetary valuation. Sensitivity analysis provides information about how changes in different variables will affect the overall costs and benefits of a proposal. It shows how sensitive predicted net benefits, and costs are, to different values of uncertain variables and to changes in assumptions. It tests whether the uncertainty over the value of certain variables matters, and identifies critical assumptions.

Due to the lack of robust evidence in the literature, and the need to estimate some of the figures in the model, a sensitivity analysis was performed. Three scenarios were chosen for the analysis:

1. Increasing provision of treatment to 80% fixed habit breaker and 20% monitoring, with no URA treatment, an ideal situation;
2. Increasing the provision of a URA to 50%, as the estimate of 23% was based on questionnaire data obtained from the previous chapter and may not be truly representative of Tayside;
3. Decreasing the success of the fixed habit breaker from 100% to 50%, as 100% was only based on one piece of literature published over 40 years ago.

The effect on the overall cost to NHS Tayside is displayed in Table 7.5.

**Table 7.5;** Sensitivity Analysis, altering current practice for thumb sucking patients.

Patient Pathway	Increasing provision of active Tx		Increasing provision of URA to 50%		Reducing success of FHB to 50%	
	NHS cost 1° care where possible	NHS cost 2° care	NHS cost 1° care where possible	NHS cost 2° care	NHS cost 1° care where possible	NHS cost 2° care
1a	£0		£0		£0	
1b	£18,457	£18,521	£41,528	£41,672	£70,757	£71,425
1c	£6,930		£15,591		£31,610	£6,770
2a	£0		£7,528		£3,463	
2b	£0	£0	£44,974	£45,105	£20,688	£20,748
2c	£0		£14,576		£6,705	
3	£23,397	£38,274	£1,462	£2,392	£731	£1,196
Total cost	£48,784	£63,724	£125,661	£126,865	£133,954	£135,254
Discounted rate	£42,156	£56,578	£100,011	£101,118	£102,554	£105,878

## 7.5 Results

Table 7.3 displays the costs for the various treatment options in different settings, with a breakdown of each cost. It demonstrates that there is a considerable saving to be made by providing a fixed habit breaker, thus preventing the need for comprehensive orthodontic treatment, whether that be in primary care or the hospital setting. The flow diagram (Figure 7.2) indicates in Tayside at present there are approximately 175 patients who have a sucking habit, 40 receiving a URA, and nine a fixed habit breaker. The current cost to NHS Tayside for digit sucking and associated malocclusion is calculated, and is presented in Table 7.4. The total is between £123,710 and £124,930, depending on the setting in which treatment is provided.

If current practice was to change, with the provision of a fixed habit breaker in preference to URA, 49 children would receive a fixed habit breaker and the cost would be as follows; 73 x pathway 1b, 4 x pathway 1c, and 49 x pathway 3. This totals £99,581 and £105,017, a difference of approximately £20,000.

The sensitivity analysis involved changing three aspects of the model;

- increasing the percentage of children receiving active treatment to 80%, all with a FHB, saving over £60,000,
- increasing the provision of a URA to 50%, increasing cost by approximately £2,000 , and
- decreasing the success of the FHB to 50%, increasing cost by approximately £10,000 .

Table 7.5 displays the results for the various changes. Further detailed spread sheets can be found in Appendix 7.

## 7.6 Discussion

The results show that there is theoretically a considerable financial saving to be made by providing fixed habit breakers, as opposed to removable habit breakers, when treating digit sucking habits. If a fixed habit breaker is provided as the

treatment of choice to children attending the dentist throughout Scotland, using the principles above and applying this to the approximate population of 107,789 nine and ten year olds who are in Scotland, there is a possible saving of £1,045,356 to £1,134,470, depending on where the care is provided. This could also potentially save 50 patients from undergoing orthognathic surgery. The saving to the NHS could be further increased if there was less active monitoring and more provision of a fixed habit breaker.

This cost analysis is the first with regard to the subject of interceptive orthodontics, and costing potential savings to the NHS, if there was a change in clinical practice. Although there have been some estimates applied in this cost analysis, the calculations for current practice in Tayside revealed that five children would eventually require combined orthodontic orthognathic treatment. Consulting records for all orthognathic surgery performed in 2010 in Tayside, there were three patients who had a history of prolonged digit sucking into their early teenage years. This would seem to demonstrate that the estimates applied to the model have projected figures which are similar to current activity.

In this study, changing the type of appliance from a removable to fixed habit breaker was investigated, and can be seen to make a significant saving to the NHS. It is likely that providing a fixed habit breaker to children with a digit sucking habit, would increase the cost to the NHS in the short-term, as currently these patients are having either psychological advice or a deterrent 'paint' applied, both of which are at no cost to the NHS. However, in the long-term there would be less development of malocclusion due to more children having stopped their habit and less need for comprehensive orthodontic treatment. This would provide a much greater saving to the NHS in the long-term.

The study only briefly touches on the fact that there is potentially an unmet need for treatment, as not all children attend the dentist regularly, and those who attend infrequently may have different priority needs such as the relief of dental pain and obtaining dental health. There is therefore a group of children who have a NNSH and who never receive the option of interceptive treatment or orthodontic treatment at a later age.



It was decided to base the costs in Scotland, using the Statement of Dental Remuneration (SDR), as currently in England, GDP contracting is based on Units of Dental Activity (UDA), with each UDA varying in value across primary care trusts. A dentist in England is required to have an orthodontic contract even to provide simple interceptive appliances, with Units of Orthodontic Activity (UOA) covering the cost. The SDR ensures the same fees are paid to GDPs and Specialist Orthodontists across Scotland for an item, and because of this consistency the study was based in Scotland.

One weakness of this study is the costings are not directly applicable to the whole of the UK, but the concept of encouraging the use of fixed habit breakers rather than monitoring, or providing an URA is important and will provide a cost saving to the NHS in England and Wales.

It is accepted that there is little high quality evidence regarding the management of NNSH, and although studies by Haryett et al. (1967, 1970) showed effective management of the habit with a fixed habit breaker, they provided no long-term follow up to demonstrate children maintained cessation of their habits. The sensitivity analysis performed in this study addresses the issue of long term success of fixed habit breakers. It shows the effect of reducing the success of fixed habit breakers to 50% has on the cost to the NHS. This is a total increase of approximately £10,000 per annum and therefore, further long-term research may be indicated. The sensitivity analysis also highlights the effect of the change to the provision of URAs from 23% to 50%, a cost increase of approximately £2,000. From the sensitivity analysis it can be seen an even larger saving could be made to the NHS Tayside, if the provision of active treatment (in the form of a fixed habit breaker) instead of monitoring, was increased to 80%. This could equate to an approximate saving of between £61,000 and £75,000.

Finally, this study did not take into account any patient/parent related factors such as acceptance or co-operation for treatment, and it may be that this would have an effect on the type of treatment provided and success. However, the potential “burden” of a fixed habit breaker may become less in the patient/parent eyes if they realise that the long-term benefits in terms of less time off school and work, and prevention of a complex malocclusion. It is important that GDPs are made aware of

the alternative of a fixed habit breaker when managing a child with a persistent digit sucking habit, and it may be that training will be required for current practice to change.

## **7.7 Conclusions**

This study has demonstrated that:

- a cost analysis can be performed for interceptive orthodontic treatment and outcome;
- a potential saving could be made to the NHS, both locally and nationally, if the provision of a removable habit breaker was changed to a fixed habit breaker;
- if the current available evidence overestimates the effectiveness of a fixed habit breaker, then the potential saving to the NHS is reduced, but only minimally; and,
- increasing the proportion receiving active treatment, in the form of a fixed habit breaker, rather than monitoring, would appear to further reduce the cost to the NHS considerably.

## **Chapter 8**

**A Proposal for an RCT; an Intervention to Increase  
the Confidence of the Providers of Interceptive  
Orthodontic Care in the Primary Dental Setting, in  
Scotland**

## **8.1 Introduction**

From the previous chapters, it can be seen there is a financial saving to be made to the NHS by providing interceptive orthodontic treatment, and GDPs feel it is their duty of care to provide this treatment. However, it is known that treatment is not always provided in the primary care setting, and Chapter 6 unearths some of the barriers to providing this care. It would appear that having the confidence to design or carry out the treatment plan, plays a large role in whether or not GDPs will provide interceptive orthodontics, as does knowledge.

## **8.2 Purpose of proposed investigation**

The purpose of this investigation is to determine whether providing GDPs with an intervention designed to increase their confidence and knowledge, with regard to carrying out interceptive orthodontic treatment, actually leads to an increase in provision of interceptive orthodontic treatment in general dental practice.

## **8.3 Background of the project**

The preceding chapters in this thesis explore and demonstrate the evidence supporting the provision of interceptive orthodontics for specific situations. Also, a significant cost saving to the NHS has been demonstrated, by theoretically changing from one treatment modality to another, and increasing the interception rate for a given scenario (prolonged thumb sucking).

It is recognised that in order to change the actions of GDPs, several factors will need to be considered. These are:

1. how to disseminate the evidence surrounding the effectiveness of interceptive treatment;
2. evidence based dentistry;
3. the psychological theories of behaviour change;
4. how to change behaviour;
5. development of complex interventions; and,
6. how to implement an intervention.

## **8.4 Literature review**

### **8.4.1 Use and effectiveness of guidelines**

Clinical guidelines have been defined as “recommendations on the appropriate treatment and care of people with specific diseases and conditions within the NHS,” and are based on the best available evidence (NICE, 2011). Guidelines help healthcare professionals in their work, but they do not replace their knowledge and skills. It would therefore seem that production of clinical guidelines regarding interceptive orthodontics, managing the mixed dentition, and appropriate referral, would be of benefit to GDPs in helping them refer only complex patients to orthodontists.

Currently, the British Orthodontic Society (BOS) has a documents describing managing the mixed dentition, and referring patients (Orthodontic Practice Committee, 2008, McNair and Morris, 2010), but the results from Chapter 6 highlight the lack of effectiveness of these documents. These results are consistent with the work by O’Brien et al. (1996), where up to 45% of orthodontic referrals are inappropriate, and provision of referral guidelines do not influence the behaviour of GDPs (O’Brien, 2000).

A Cochrane systematic review investigated the effects of guidelines, along with other printed educational materials (PEMs), on professional practice, and health care outcomes (Giguère et al., 2012). The review included 45 studies, randomised controlled trials, controlled clinical trials, controlled before and after studies, and interrupted time series analyses, which evaluated the impact of printed educational materials on healthcare professionals' practice and/or patient outcomes. The evidence showed PEMs have small beneficial effects on professional practice, but not on patient outcomes. It would appear that although guidelines, in theory, could be the answer to improving practice, their uptake and application is not a simple process.

Potential benefits of guidelines for healthcare professionals have been identified as improving the quality of clinical decisions, supporting quality improvement activities (audit) by giving a standard to adhere to, and for medico-legal protection (Eccles and Grimshaw, 2000). However, guidelines can often highlight the gaps in the literature and unanswered research questions. Often there is little evidence surrounding a topic and guidelines are then influenced by opinions and clinical

experience of the group developing the guidelines. Another bias can be introduced by service providers, who are often keen on the implementation of guidelines, as they tend to improve efficiency and cost effectiveness (Shapiro et al., 1993).

The development of The National Institute for Health and Clinical Excellence (NICE), and The Scottish Intercollegiate Guidelines Network (SIGN) has ensured that the production of healthcare guidelines, for the NHS, are based on current evidence, and this evidence is given a weighting. Both parties were set up in the 1990s to improve the quality of health care, and reduce variation in practice and outcome.

#### **8.4.2 Evidence based dentistry**

The vision of evidence based medicine (EBM) was introduced in the early 1990s (Guyatt, 1991), and brought together the idea of using current evidence to inform clinical decision-making. EBM has been defined as “the conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients” (Sackett et al., 1996). Shortly after this, evidence based dentistry (EBD) emerged (Richards and Lawrence, 1995), with a journal dedicated to the subject with the aim of “Bridging the gap between research and dental practice.” Five steps to evidence based practice have been described (Cook et al., 1992, Dawes et al., 2005):

1. Translation of uncertainty to an answerable question;
2. Systematic retrieval of best evidence available;
3. Critical appraisal of evidence for validity;
4. Clinical relevance; and,
5. Applicability, application of results in practice, and evaluation of performance.

The literature has many publications on interventions which promote evidence based practice, and there are systematic reviews of these publications, with one overview of reviews being commonly quoted (Bero et al., 1998). This paper included 18 reviews, and concluded that systematic reviews of rigorous studies provide best evidence for the effectiveness of different strategies to promote the implementation of research findings. But often there are no rigorous studies in certain areas from which to conduct a systematic review. Passive dissemination of information is generally ineffective, and it is necessary to use specific strategies to encourage implementation of research based recommendations, ensuring changes in practice

occur. Bero et al. (1998) suggest further research is required on the relative effectiveness and efficacy of different strategies, but found the following to be consistently effective interventions:

- educational outreach visits;
- reminders (manual or computerised);
- multifaceted interventions (a combination of two or more of the following: audit and feedback, reminders, local consensus processes, or marketing); and,
- interactive educational meetings (participation of healthcare providers in workshops which include discussion or practice).

They also found that didactic teaching had little or no effect.

Abt et al. (2004) give an excellent account of the barriers preventing incorporation of research into medical and dental practice. Two of the main components are the practitioners' ability to recognise the need for change, and the ability to change behaviour.

A recent study explored which type of evidence has an impact on dentists' willingness to change their behaviour (Wårdh et al., 2009). They found that dentists mainly seek new knowledge from colleagues, and the most appealing way of receiving new knowledge was through educational conferences. Dentists reported difficulties in evaluating new knowledge, requiring a transfer process before the ideas could be implemented in practice.

Further research looking at the barriers to implementation of evidence based guidelines, found the most common barriers were; difficulty in changing current practice, resistance and criticism from colleagues, lack of trust in evidence or research, and lack of time to search for guidelines or practice EBD (Spallek et al., 2010).

#### **8.4.3 Psychological theories and changing behaviour**

Potential barriers to change, with regard to getting research findings into practice, have been listed as (Haines and Donald, 1998, 2002):

1. the practice environment;
2. the educational environment;
3. the healthcare environment;
4. the social environment;
5. practitioner factors; and,

## 6. patient factors

Theories and models help to explain, predict, and understand health behaviour, providing a foundation or framework from which educational interventions can be designed, leading to improvement in health status (Hayden, 2009). Theory has been defined as a set of interrelated concepts, definitions, and propositions. These present a systematic review of events or situations, by specifying relationships between variables, in order to explain and predict events or situations (Glanz et al., 2002). A multitude of factors influence the type of behaviours in which people engage. These factors include socioeconomic status (education, income and occupation), skills, culture (accepted norms), beliefs, attitudes, values, religion and gender (Hayden, 2009). Beliefs form the concept of the self-efficacy theory (derived from the social cognitive theory) and the health belief model, whereas attitudes surround the basis of the theory of planned behaviour.

The most commonly known theory of change is that developed by DiClemente and Prochaska (DiClemente and Prochaska, 1982), the transtheoretical model of behaviour change. It involves ten processes of change:

1. consciousness raising;
2. self-liberation;
3. social liberation;
4. self-re-evaluation;
5. environmental re-evaluation;
6. counterconditioning;
7. stimulus control;
8. reinforcement management;
9. dramatic relief; and,
10. helping relationships.

It also involves five stages of change: pre-contemplation; contemplation; action; maintenance; and relapse. Each of the stages requires tasks to be completed before the individual can proceed to the next stage. Interventions to help people move through the stages rely on matching the intervention to the stage each person is currently in (Ramseier and Suvan, 2010).

The health belief model endeavours to explain and predict health behaviours by concentrating on the attitude and beliefs of individuals (Becker and Maiman, 1975).

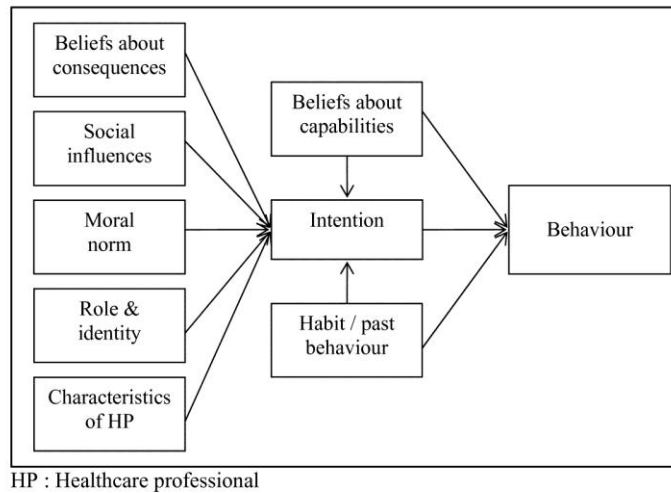


It is commonly used in health education and health promotion. It has been used in dentistry to explain patient behaviours particularly around the subjects of oral hygiene and periodontal disease (Anagnostopoulos et al., 2011, Barker, 1994, Borkowska et al., 1998, Buglar et al., 2010, Reisine and Litt, 1993, Renz et al., 2007). The model focuses around four perceptions; namely perceived seriousness, perceived susceptibility, perceived benefits, and perceived barriers.

Self-efficacy theory was developed by Bandura (Bandura, 1977, Bandura and Adams, 1977) and built on his earlier work of the social cognitive theory. Bandura claims perceived self-efficacy not only influences choice of activities but, through expectations of eventual success, it can affect persistence of coping efforts when an activity is initiated. Efficacy expectations are likely to determine how much effort people will expend, and how long they will persist in the face of obstacles and aversive experiences. The stronger the efficacy or mastery expectations, the more active the efforts (Bandura et al., 1977). Dental self-efficacy has been shown to be correlated with dental caries (Knecht et al., 1999), and the assessment and enhancement of oral-care specific self-efficacy is important to promote behaviour modification in clinical dental practice (Kakudate et al., 2010).

Theory of planned behaviour (TPB) proposes behaviour is based on intention. Intentions to perform behaviours of different kinds can be predicted with high accuracy from attitudes toward the behaviour, subjective norms, and perceived behavioural control. These intentions, together with perceptions of behavioural control, account for considerable variance in actual behaviour (Ajzen, 1991). This theory also includes volitional control, the extent to which we can decide to do something, at will. Put simply, the best predictor of behaviour is a person's intention to perform that behaviour (Ramseier and Suvan, 2010).

A systematic review looking at healthcare professionals' intentions and behaviours, based on social cognitive theories, concluded that the TPB is an appropriate theory to predict behaviour. However, Triandis' theory, which incorporates moral norm and role beliefs, is better for intention (Godin et al., 2008). The authors have devised a theoretical framework for the study of behaviour and intention, and it is shown in Figure 8.1.



**Figure 8.1;** Godin's theoretical framework.

#### 8.4.4 Changing behaviour

NICE have produced guidance on the most appropriate generic and specific interventions to support attitude and behaviour change, at population and community levels (NICE, 2007). The aim of this document is to help professionals help patients change their behaviour, leading to healthier lives. There are eight principles:

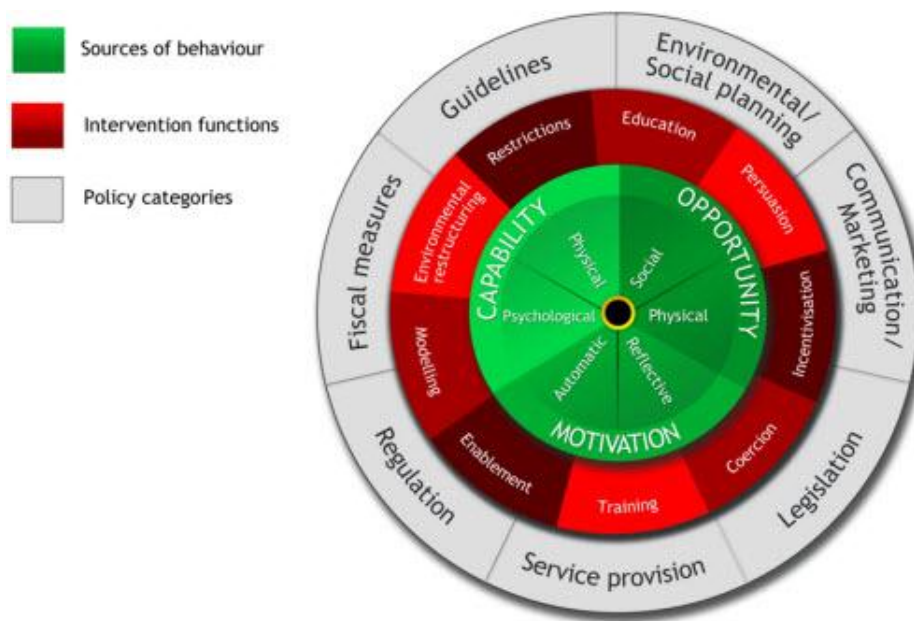
1. planning interventions and programmes;
2. assessing social context;
3. education and training;
4. individual-level interventions and programmes;
5. community-level interventions and programmes;
6. population-level interventions and programmes;
7. evaluation effectiveness; and,
8. assessing cost effectiveness.

Despite this guidance being aimed at changing patient behaviour, some of the recommended action detailed in principle five, is worth considering. They mention improving self-efficacy, developing and maintaining supportive social networks, and nurturing relationships, as well as building skills, and promoting access to the financial and material resources needed to aid behaviour change.

Michie et al. (2005) have developed a set of theoretical constructs for use in studying the implementation of evidence based practice and for developing strategies for effective implementation. They identified 12 domains to explain behaviour change: knowledge; skills; social/professional role and identity; beliefs about capabilities;

beliefs about consequences; motivation and goals; memory, attention and decision process; environmental context and resources; social influences; emotion regulation; behavioural regulation; and, nature of the behaviour.

Michie et al. (2011) have continued working in this field, and have designed the “behaviour change wheel,” a method for characterising and designing behaviour change techniques (Figure 8.2). They felt in order for intervention design to improve, a systematic method was needed which includes an understanding of the nature of the behaviour to be changed, along with a system for distinguishing interventions and their components. At the centre of the wheel are three essential conditions: capability, opportunity, and motivation. These are surrounded by nine intervention functions aimed at addressing deficits in one or more of these conditions. Around this are placed seven categories of policy which could enable those interventions to occur. Using this wheel to increase self-efficacy, it would seem that the interventions most suited would be modelling, education, and training.



**Figure 8.2;** Behavioural change wheel (Michie et al., 2011).

#### 8.4.5 Developing and implementing interventions

Complex interventions have been defined by the Medical Research Council (MRC) as interventions which contain several interacting components. The MRC has produced guidance on developing and evaluating complex interventions (Craig et al.,

2008a, 2008b). The purpose of the document is to provide guidance on the development, evaluation, and implementation of complex interventions to improve health, and it replaces a previous document produced in 2000. One of its main aims is to help researchers choose appropriate methods for their intervention. The MRC divides the process into 5 stages; developing an intervention; piloting, evaluating, reporting, and implementation of the complex intervention. At each stage the researcher should be asking key questions, some of which are listed in Table 8.1.

**Table 8.1;** Questions to be asked during the design of a complex intervention.

<b>Developing</b>	<b>Piloting</b>	<b>Evaluation</b>	<b>Reporting</b>	<b>Implementing</b>
How will you bring about change?	Have you done enough piloting work to be confident	What design are you going to use, and why?	Have you reported your evaluation appropriately?	Are your results accessible to decision makers, and are they presented in a persuasive way?
Does your intervention have a theoretical basis?	the intervention can be delivered as intended?	Is an experimental design preferable and is it feasible?		

Further questions that the MRC feel may be of use as the researcher approaches the evaluation of a complex intervention are:

1. Have you conducted a systematic review?
2. Who is the intervention aimed at?
3. Can you describe the intervention fully?
4. How variable is the intervention – between sites, over time, etc?
5. Can you describe the context and environment in which the evaluation is being undertaken?
6. What user involvement is there going to be in the study?
7. Is your study ethical?
8. What arrangements will you put in place to monitor and oversee the evaluation?
9. Have you reported your evaluation appropriately?
10. How will you analyse the data?

The challenges surrounding designing and evaluating complex interventions are clearly explored in the work by Bonetti and Clarkson (2010), beginning with the design and decisions about the specific behaviour to be targeted, and the overall aim(s). They recommend using theories to inform the design of the intervention, and to help further the understanding of the intervention effect. Another challenge is “to identify the process by which the intervention is to generate the desired change in the behavioural target(s).” The authors recognise that there is no single theory or intervention which is the “magic bullet” for facilitating professional behaviour change. Also, there is the challenge of how to test the intervention, particularly as this may not be possible within the constraints of the NHS, followed by how to evaluate the impact of the intervention. Furthermore, by inviting health care professionals to participate in a trial, we are already introducing a bias by making that professional sensitised to the subject under investigation.

#### **8.4.6 Summary**

From the literature it can be seen that designing a complex intervention to change behaviour is challenging. Disseminating printed educational material is ineffective at changing practice. Various psychological theories have been developed to explain behaviour and suggest ways to change behaviour. Self-efficacy seems to play an important role in changing behaviour, and can be increased through targeted training involving modelling.

### **8.5 Plan of proposed investigation**

The design of this investigation will be a cluster randomised controlled trial, using modelling (tell, show, do) as the intervention. The aim will be to increase the confidence and knowledge of GDPs surrounding the provision of interceptive orthodontics in primary dental care.

#### **8.5.1 Hypotheses to be tested**

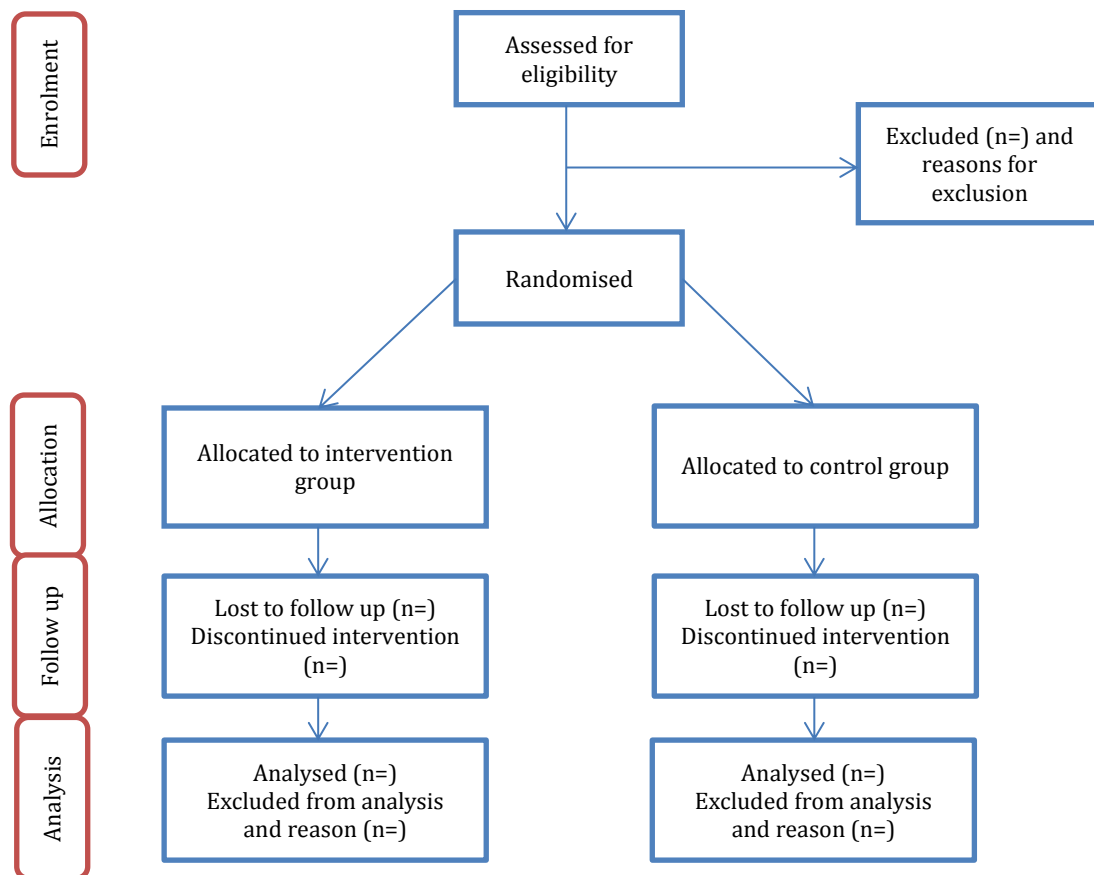
Completing a training package, designed to increase confidence and knowledge, increases GDPs confidence and knowledge in the field of interceptive orthodontics.

*Null hypothesis;* a targeted intervention to increase GDPs confidence, and knowledge, on the subject of interceptive orthodontics does not improve either.

### 8.5.2 Study design

This study will be a multi-centred cluster randomised controlled trial, carried out across Scotland. Practices will be assigned to either the control arm, or the intervention arm of the study.

Pre-intervention, all participants will complete an online questionnaire comprising clinical scenarios in which the children would benefit from interceptive orthodontics. The questions will test either confidence (specifically self-efficacy, relating to how effectively the plan can be carried out for the patient, and designing the plan), or knowledge. Following this, and after randomisation, those in the control arm will receive a copy of the two BOS documents describing managing the mixed dentition, and referring patients (Orthodontic Practice Committee, 2008, McNair and Morris, 2010). Practices assigned to the intervention group will receive a face to face small group training session, in their practice. Figure 8.3 displays the proposed study pathway.



**Figure 8.3;** CONSORT type diagram for proposed investigation.

### **8.5.3 Subjects and setting**

The participants will be GPs currently working in Scotland, who treat children on the NHS.

### **8.5.4 Inclusion criteria**

Dentists who are fully registered with the GDC and working in general dental practice will be eligible to participate. Dentists will have to have a minimum of 10% children on their list, and have internet access.

### **8.5.5 Exclusion criteria**

Practices which have a dentist with a recognised specialist interest in orthodontics or paediatric dentistry will be excluded, as will practices which have a Specialist Orthodontist or a Specialist Paediatric Dentist.

### **8.5.6 Interventions**

The intervention will involve a knowledge component and a clinical component. For the knowledge component, current evidence based treatment plans will be discussed for a variety of situations, which require interceptive orthodontic management.

To increase confidence, scenarios will be presented by an orthodontist who will describe, in detail, their thought process when deciding on the most appropriate treatment for children, who would benefit from interceptive orthodontics (IO).

Scenarios will also be included with children who would not benefit from IO, with a detailed explanation of the reason why treatment is not recommended. This will be followed by further scenarios, which will be given to the dentists and they will have to decide upon the appropriate treatment.

The scenarios will include; history of the case, extra and intra-oral photographs and radiographs where applicable. There will be scenarios for the group to work through (dentists in the practice), then scenarios to be completed on an individual basis.

Group, and one to one, feedback will be given at the end of each task.

The control group will receive the same scenarios, and instructions on how to apply the guidelines to the scenarios.

All participants, control and intervention, will complete a picture test on line, of clinical scenarios, one month after the intervention to assess effectiveness of the intervention. Questions will assess either confidence or knowledge.

### **8.5.7 Data collection and analysis**

Pre and post intervention questionnaire data will be coded, and input into SPSS v 19 for analysis. Confidence will be recorded on a Likert scale of one to ten, and knowledge will be recorded as a percentage score. Means, SD and ranges will be calculated.

### **8.5.8 Outcomes**

The primary outcome will investigate the level of confidence regarding the provision of interceptive orthodontic for given scenarios post training.

The secondary outcome will investigate the level of knowledge post training.

### **8.5.9 Sample size calculation**

The sample size calculation will be based on the primary outcome, level of confidence, following the intervention. It has been decided that a finding of a difference of two points (20%) in the mean score for confidence in the GDPs responses would be significant enough to show a difference in their clinical behaviour, and assume a SD = 2 points. For this calculation it has been accepted an average dental practice has three dentists.

A preliminary power analysis with a power of 0.8, and a two-sided alpha of 0.05, suggests that a minimum sample of  $n = 17$  in each arm would be required to detect a difference of 2 points, assuming a SD = 2 points, giving a total of  $N = 34$ . As the design is clustered this would have to be inflated, to allow for correlation within dental practices.

The inflation factor  $IF = 1 + (m - 1) \rho$

$m$  = average practice size

$\rho$  = intra-cluster correlation.

Assuming  $m = 3$ , and  $\rho = 0.05$ , gives  $IF = 1.1$ , the sample size is inflated to  $N = 37$  ( $N$  = number of practices). In addition, allowing for drop-out of 10% means that the trial should aim for  $N = 41$ .

### **8.5.10 Randomisation**

Randomisation will take place using an online randomisation system, with stratification for age (22 to 35 years old, 36 to 49 years old, 50 years old and over).

### **8.5.11 Statistical analysis plan**

Data will be checked for normality of distribution and any evidence of skewness.

Descriptive statistics will be prepared. Appropriate parametric or non-parametric



analysis will be undertaken to determine statistically significant differences in the outcomes listed above between the control and intervention groups.

#### **8.5.12 Impact**

It is hoped that the intervention will greatly improve the knowledge and confidence GPs have surrounding interceptive orthodontics, leading to an increased awareness and more active management of these conditions in primary care. If this intervention is successful consideration will be given to a UK based intervention.

## **Chapter 9**

### **Conclusions and Future Plans**

## 9.1 Conclusions

The aims of this thesis were several;

1. To systematically review evidence in areas where it was currently lacking;
2. To investigate GDPs attitudes, beliefs and knowledge surrounding IO;
3. To investigate potential cost savings of implementing IO in primary care;
4. To design an interventional study to translate these findings into practice.

The findings are:

1. The literature surrounding the management of anterior crossbites is poor.  
There are many reported techniques but a fixed “2 x 4” appliance appears to be effective;
2. Although there were RCTs investigating cessation of NNSHs, due to the heterogeneity of the studies, they could not be combined. There was weak evidence suggesting a fixed habit breaker was successful in stopping children suck their thumb;
3. Semi-structured interviews exploring GDPs thoughts surrounding IO in primary care identified three themes; motivational factors, barriers and excuses to providing treatment;
4. The results from the questionnaire showed the main barrier to providing treatment was associated with self-efficacy surrounding generally carrying out IO, along with self-efficacy generally design treatment plans for these patients. These two items had a high bivariate correlation and could not be separated, therefore are regarded as one. Therefore, the hypothesis that dentists possess the attitude to provide IO in primary care was rejected;
5. Other barriers were identified, these were GDP knowledge and age.  
Therefore, the hypothesis that dentists possess the knowledge to provide IO in primary care was rejected;
6. No barriers were identified relating to beliefs, therefore, the hypothesis that dentists possess the beliefs to provide IO in primary care was accepted.
7. From a cost perspective, changing the way GDPs manage children with a NNSH, by getting them to provide a fixed habit breaker (FHB), appears to generate a financial saving to the NHS Tayside in the region of £20,000.

Therefore, the hypothesis that there is cost saving to be made to NHS Tayside by increased provision of IO in primary care was accepted;

8. If behaviour change was to occur across Scotland, providing a FHB to all children with a NNSH, this saving could increase to over £1,000,000.

Therefore, the hypothesis that there is a cost saving to be made to NHS Scotland by increasing provision of IO in primary care was accepted;

9. It was possible to design an interventional study aimed at GDPs using the information found by analysing the questionnaire. This study is based on the technique of modelling, to increase GDPs confidence and knowledge;

## **9.2 Future plans**

### **9.2.1. Implementing the intervention**

It is hoped that funding can be secured to allow the study outlined in Chapter 8 to proceed. If it was found that the intervention is effective, perhaps this intervention could be rolled out across the UK.

### **9.2.2 Increasing the body of evidence**

Interceptive orthodontics is a broad topic, and this thesis has not thoroughly explored all subjects pertaining to it. An area of particular interest, due to the frequency the problem occurs, is the extraction of poor prognosis first permanent molars at an appropriate time. There is uncertainty amongst clinicians whether a sound upper first molar should be extracted at the time of the lower. There are guidelines offering advice on this subject, produced by the Royal Colleges of Surgeons of England.

These recommend in a Class I occlusion, a compensating extraction should be performed when extraction of the lower first permanent molar occurs. Regrettably, these guidelines are based on weak evidence. The question of whether or not to perform a compensating extraction when extracting a lower first permanent molar still needs to be answered. It may be children are having to endure unnecessary extractions, not to mention quality of life issues for children and parents, and avoidable costs to the NHS. This had led to the development of a multi-site parallel arm randomised controlled trial to be set up, with the details of the protocol available in the literature (ClinicalTrials.gov, 2012). The trial aims to determine whether or

not the upper first permanent molar needs to be extracted when extracting the lower, and following the results of the study, the guidelines will either require changing, or be shown to have a sound evidence base.

### **9.3 Concluding comments**

It is hoped that the work submitted in this thesis is the starting block for further work in the field of implementing interceptive orthodontics in primary dental care, and the body of evidence continues to be improved, ensuring evidence base dentistry is practised in this field.

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## **Appendix 1**

### **Search Strategy for NNSH Systematic Review**

### 1 MEDLINE (OVID) search strategy

1. Sucking behavior/
2. (suck\$ and (habit\$ or behav\$ or routine\$)).mp.
3. ("non nutritive suck\$" or "non-nutritive suck\$" or "nonnutritive suck\$").mp.
4. or/1-3
5. Pacifiers/
6. Fingersucking/
7. (pacifier\$ or digit\$ or dummy or dummies or soother\$ or blanket\$ or finger\$ or thumb\$).mp.
8. or/5-7
9. 4 and 8

The above subject search was linked to the Cochrane Highly Sensitive Search Strategy (CHSSS) for identifying randomized trials in MEDLINE: sensitivity maximising version (2008 revision) as referenced in Chapter 6.4.11.1 and detailed in box 6.4.c of *The Cochrane Handbook for Systematic Reviews of Interventions*, Version 5.1.0 (Higgins and Green, 2011).

1. randomized controlled trial.pt.
2. controlled clinical trial.pt.
3. randomized.ab.
4. placebo.ab.
5. drug therapy.fs.
6. randomly.ab.
7. trial.ab.
8. groups.ab.
9. or/1-8
10. exp animals/ not humans.sh.
11. 9 not 10

### 2 Cochrane Oral Health Group Trials Register search strategy

(suck\* AND (pacif\* or dumm\* or digit\* or finger\* or thumb\* or soother\* or blanket\* or non-nutriti\* or "non nutriti\*" or nonnutriti\*))

### 3 CENTRAL search strategy

- #1 MeSH descriptor Sucking behavior this term only
- #2 (suck\* in All Text and (habit\* in All Text or behav\* in All Text or routin\* in All Text))
- #3 (suck\* in All Text and (non-nutrit\* in All Text or "non nutriti\*" in All Text or

nonnutrit\* in All Text))

#4 (#1 or #2 or #3)

#5 MeSH descriptor Pacifiers this term only

#6 MeSH descriptor Fingersucking this term only

#7 (pacifier\* in All Text or digit\* in All Text or dummy in All Text or dummies in All Text or soother\* in All Text or blanket\* in All Text or finger\* in All Text or thumb\* in All Text)

#8 (#5 or #6 or #7)

#9 (#4 and #8)

#### 4 EMBASE (OVID) search strategy

1. Sucking behavior/
2. (suck\$ and (habit\$ or behav\$ or routine\$)).mp.
3. ("non nutritive suck\$" or "non-nutritive suck\$" or "nonnutritive suck\$").mp.
4. or/1-3
5. Pacifiers/
6. Fingersucking/
7. (pacifier\$ or digit\$ or dummy or dummies or soother\$ or blanket\$ or finger\$ or thumb\$).mp.
8. or/5-7
9. 4 and 8

The above subject search was linked to the Cochrane Oral Health Group filter for EMBASE via OVID:

1. random\$.ti,ab.
2. factorial\$.ti,ab.
3. (crossover\$ or cross over\$ or cross-over\$).ti,ab.
4. placebo\$.ti,ab.
5. (doubl\$ adj blind\$).ti,ab.
6. (singl\$ adj blind\$).ti,ab.
7. assign\$.ti,ab.
8. allocat\$.ti,ab.
9. volunteer\$.ti,ab.
10. CROSSOVER PROCEDURE.sh.
11. DOUBLE-BLIND PROCEDURE.sh.
12. RANDOMIZED CONTROLLED TRIAL.sh.
13. SINGLE BLIND PROCEDURE.sh.
14. or/1-13
15. ANIMAL/ or NONHUMAN/ or ANIMAL EXPERIMENT/
16. HUMAN/
17. 16 and 15

18. 15 not 17

19. 14 not 18

## 5 PsycINFO (OVID) search strategy

1. exp Sucking/
2. (suck\$ and (habit\$ or behav\$ or routine\$)).mp.
3. ("non nutritive suck\$" or "non-nutritive suck\$" or "nonnutritive suck\$").mp.
4. or/1-3
5. (pacifier\$ or digit\$ or dummy or dummies or soother\$ or blanket\$ or finger\$ or thumb\$).mp.
6. 4 and 5

The above subject search was linked to the Cochrane Oral Health Group filter for PsycINFO via OVID:

1. exp clinical trials/
2. (clin\$ adj25 trial\$).ti,ab.
3. placebo\$.ti,ab.
4. random\$.ti,ab.
5. ((randomised adj controlled adj trial\$) or (randomized adj controlled adj trial\$)).mp.
6. (controlled adj clinical adj trial\$).mp.
7. (random adj allocat\$).mp.
8. ((singl\$ or doubl\$ or trebl\$ or tripl\$) adj25 (blind\$ or mask\$)).ti,ab.
9. (control\$ adj4 trial\$).mp.
10. (ANIMALS not HUMANS).sh.
11. or/1-9
12. 11 not 10

## 6 CINAHL (EBSCO) search strategy

- S1 MH "Sucking Behavior"
- S2 (suck\* and habit\*) or (suck\* and behav\*) or (suck\* and routine\*)
- S3 "non nutritive suck\*" or "nonnutritive suck\*" or "non-nutritive suck\*"
- S4 S1 or S2 or S3
- S5 MH Pacifiers
- S6 pacifier\* or digit\* or dummy or dummies or soother\* or blanket\* or finger\* or thumb\*
- S7 S5 or S6
- S8 S4 and S7

The above subject search was linked to the Cochrane Oral Health Group filter for CINAHL via EBSCO:

- S1 MH Random Assignment or MH Single-blind Studies or MH Double-blind Studies or MH Triple-blind Studies or MH Crossover design or MH Factorial Design
- S2 TI ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study") or AB ("multicentre study" or "multicenter study" or "multi-



centre study" or "multi-center study") or SU ("multicentre study" or "multicenter study" or "multi-centre study" or "multi-center study")

S3 TI random\* or AB random\*

S4 AB "latin square" or TI "latin square"

S5 TI (crossover or cross-over) or AB (crossover or cross-over) or SU (crossover or cross-over)

S6 MH Placebos

S7 AB (singl\* or doubl\* or trebl\* or tripl\*) or TI (singl\* or doubl\* or trebl\* or tripl\*)

S8 TI blind\* or AB mask\* or AB blind\* or TI mask\*

S9 S7 and S8

S10 TI Placebo\* or AB Placebo\* or SU Placebo\*

S11 MH Clinical Trials

S12 TI (Clinical AND Trial) or AB (Clinical AND Trial) or SU (Clinical AND Trial)

S13 S1 or S2 or S3 or S4 or S5 or S6 or S9 or S10 or S11 or S12

## **Appendix 2**

### **Data Extraction Form**

**Interventions for the cessation of pacifier or digit sucking habits in children: Data extraction form**

Study ID:		Authors:	
Year:		Country:	
Habit Type (circle as appropriate): A = digit sucking B = any other		Care Setting (primary/ secondary/community)	
Study design:		Funding agency/ Ethical approval	
	<b>Group 1</b>	<b>Group 2</b>	<b>Group 3</b>
Intervention, including duration of intervention			
Number recruited			
Number analysed			
Age (range, mean, SD)			
Gender (M:F)			
Duration of follow up period			
	<b>Group 1</b>	<b>Group 2</b>	<b>Group 3</b>
Cessation of habit (proportion etc)			
Discomfort from intervention			
Psychological effects of intervention			
Reduction in AOB			
Reduction in OJ			
Correction of posterior X-bite			
Time taken to be effective			
Reviewer comments:			

## **Appendix 3**

### **Characteristics of included studies**

**Azrin, 1980****Methods**

Location: USA

Setting: Secondary care

No mention of funding or ethical approval

**Participants**

Children with digit sucking habits, aged 2.5 to 14 years with mean age of 8.3 years.

Recruitment through self-referral following a newspaper advertisement.

32 recruited and data for 30 analysed, 2 lost to follow up

**Interventions****Habit reversal (HR)**

A single counselling session (n=18)

Part 1, the children were taught competing behaviours such as making a fist or grasping a convenient object for 1-3 minutes (measured by counting to 100).

Part 2, children described the intervention to their parent and requested parental assistance.

Part 3, “annoyance review” in which the child listed all the problems created by thumb sucking and “heightened awareness” in which the child acted out the usual response sequence including the precursors of thumb sucking to identify the stimulus antecedents. Parents were instructed to provide social support by praising the child when sucking was absent, and providing treats and surprises when sucking was absent for an extended period. When sucking occurred the children were prevented from watching television or from having bedtime stories.

**Aversive tasting substance application (ATSA)**

The parents of the children (n=12) received a single phone call informing them about the use of a commercially available aversive tasting substance to be applied morning and evening.

**Outcomes**

1. Percentage of children with no thumb sucking at 3 months.
2. Mean number of episodes per day in each group.

**Christensen and Sanders, 1987**

<b>Methods</b>	<p>Location: Australia</p> <p>Setting: recruitment in secondary care, intervention at patients' home</p> <p>No mention of funding or ethical approval</p>
<b>Participants</b>	<p>Children age range 4 to 9 years and mean 6.3 years, 43% female and 57% male.</p> <p>A newspaper article invited parents "to apply for inclusion in the programme if they were experiencing difficulty with their child's thumb-sucking behaviour."</p> <p>30 recruited and analysed, no loss to follow up</p>
<b>Interventions</b>	<p><b>Habit reversal (HR)</b></p> <p>For the HR and DRO groups, parents identified a home setting associated with high levels of thumb-sucking (TV viewing). This setting served as the training setting. Two other settings were identified; generalising setting one, with high levels of thumb sucking were seen, and generalization setting two, which was thumb sucking at bedtime. Observations of the child in the training setting were conducted at baseline and on two different days in each phase for the HR and DRO groups and follow up for the control group. Observations were scheduled to coincide with a time when the child usually watched TV, or was at play, depending on what had been selected by the parents as the training setting.</p> <p>Parents were instructed to involve their child (n=10) in a discussion about working together for the next 10 days to overcome the habit, with the child identifying the stimulus conditions associated with thumb sucking. The parents provided feedback on how the competing response exercise was to be performed. This involved clenching both fists and counting to 20. Parents were instructed to carry out the procedures for 10 consecutive days.</p> <p><b>Differential reinforcement of other behaviour (DRO)</b></p> <p>This was an escalating schedule of reinforcement, contingent upon non-occurrence of thumb sucking, and was implemented in two phases. Parents discussed with the child (n=10) how they</p>

would be working together for the ten days to overcome the habit. Privileges could be earned by not thumb sucking, and there would be daily rules for which tokens could be earned, and exchanged for these privileges. The child selected the reward they would like to earn in exchange for the tokens that day. The training period continued for ten consecutive days. Three months after the termination of training, two further observation sessions were conducted in each setting.

### **Waiting list control group**

This group received no treatment (n=10).

- |                 |  |
|-----------------|--|
| <b>Outcomes</b> | <ol style="list-style-type: none"> <li>1. cessation of habit (%) - post treatment and 3 months follow up</li> <li>2. proportion of time spent sucking - baseline to follow up</li> <li>3. psychological effects - oppositional behaviour - baseline to follow up</li> <li>4. parents recommendation of intervention</li> </ol> |
|-----------------|--|

### **Friman and Leibowitz, 1988**

- |                      |   |
|----------------------|---|
| <b>Methods</b>       | <p>Location: USA</p> <p>Setting: Participants' home and Secondary care</p> <p>Funded by the US department of health and human services</p>  |
| <b>Participants</b>  | <p>Children 4 years of age or older, with a chronic habit, and a high level of parental concern about the habit. Age range of 4 to 11.6 years.</p> <p>Twenty four patients referred from the patients' local paediatric provider met the inclusion criteria however, 2 did not complete baseline questionnaires and were excluded.</p>  |
| <b>Interventions</b> | <p><b>Aversive taste treatment and reward system</b></p> <p>The parents were instructed to coat their child's thumbnail with a commercially available substance designed to treat thumb sucking (n=11). It was applied once in the morning when the child awoke, once just before bed, and once each time an instance of sucking was observed. A fading procedure was used to discontinue the treatment, which involved eliminating the</p> |

morning application after having one week where sucking was not observed. The evening application was discontinued after an additional week with no sucking. The reward system required the preparation of 50-100 slips of paper on which the parents had written a variety of treats, with a value less than \$10. These slips of paper were placed in a grab bag, and the participants were allowed to take one when an observed instance of non thumb sucking occurred.

### **Control group**

This group did not receive any treatment (n=11).

- Outcomes**
1. percentage intervals with observed thumb sucking - immediately post treatment compared with pre treatment
  2. acceptability of intervention - 7 point scale.

### **Haryett et al., 1967**

- Methods**
- Location: Canada
  - Setting: participants' home and secondary care
  - No mention of funding or ethical approval
- Participants**
- Children 4years old and older
  - Participants were referred by dentists
  - Digit suckers
  - 66 patients were recruited, one lost to follow up, 65 analysed
- Interventions**
- Control group**
- This group received no treatment (n=10)
- Psychological treatment**
- The psychological intervention involved two parts. Firstly, gaining the child's co-operation in breaking the thumb sucking habit by showing them in a mirror what the habit had done to the position of their own teeth, showing them photos and models of thumb suckers and creating a desire to break the habit. Secondly, the parent, usually the mother, was given instructions to reward periods where thumb sucking did not take place. The reward was



giving the child their full attention, and ignoring them if the habit occurred (n=11).

### **Palatal arch**

An appliance banded to either the maxillary second deciduous molars or first permanent molars, with a stainless steel wire fitted behind the upper incisors on the gingival margins of the palatal aspect of the upper incisors (n=11).

### **Palatal arch and psychological treatment**

A combination of the two techniques described above (n=11).

### **Palatal crib**

An appliance banded to either the maxillary second deciduous molars or first permanent molars, with stainless steel wire fitted behind the upper incisors, over the palatal rugae with “vertical fence-like projections extended as deep as the lateral excursions of the mandible will allow” (n=11).

### **Palatal crib and psychological treatment**

A combination of the palatal crib treatment and psychological treatment described (n=11).

The participants were randomly assigned to one of the 6 groups. All treatment lasted 10 months and after this, where appropriate, orthodontic appliances were removed.

## **Outcomes**

The outcomes were measured one month after the intervention had stopped.

1. Cessation of habit (expressed both as number of participants and %) at 1 month, 1 year, 2 years and 3 years
2. Discomfort from intervention - upset and eating difficulty
3. Psychological effects - development of mannerisms

## **Larsson, 1972**

### **Methods**

Location: Sweden

Setting: Participants' home and secondary care

<b>Participants</b>	<p>Children 9 years old</p> <p>Patients were identified following an incidence study (Larsson 1971) which investigated pacifier and finger sucking in 920 nine year old children resident in a particular area of Sweden.</p> <p>Digit suckers</p> <p>76 recruited and analysed immediately post intervention. One lost to follow up at one year.</p>
<b>Interventions</b>	<p><b>Positive reinforcement</b></p> <p>Participants' mothers were given specific instructions about different forms of encouragement, and reinforcement was also given by a psychologist (n=19).</p> <p><b>Negative reinforcement</b></p> <p>Children and their parents were given information about the consequences and risks of prolonged finger sucking. They were given models of the children's teeth home with them (n=19).</p> <p><b>Palatal crib</b></p> <p>The palatal crib had spurs welded to bands cemented to the maxillary first molar teeth. "The crib lay a millimetre or so from the mucosa and extended just behind the maxillary incisors. The spurs were rounded in front and so adjusted that they did not disturb the occlusion" (n=19).</p> <p><b>Control</b></p> <p>No treatment was provided to this group (n=19).</p> <p>All interventions lasted 2 ½ months, following which all appliances were removed and the children were examined by psychologists.</p>
<b>Outcomes</b>	<ol style="list-style-type: none"> <li>1. Cessation of habit (% and n) immediately post intervention,</li> <li>2. Cessation of habit (% and n) 6 months after completion of treatment</li> <li>3. Cessation of habit (% and n) 1 year after completion of treatment.</li> </ol>

**Villa, 1997****Methods**

Location: USA

Setting: secondary care

No mention of funding or ethical approval

**Participants**

Children aged 8 to 18 years

Participants were selected following a 4 month screening in a medical centre.

Digit suckers

24 recruited and analysed

**Interventions****Palatal crib therapy**

There was no mention of the specific design of this appliance therefore it was assumed it was similar in design to that described by Haryett and Larsson (n=12).

**Control**

This group received no treatment (n=12)

Pre-treatment records were taken for the participants and included study models, OPT, lateral cephalogram radiographs, and intra and extra oral photographs. After 3 months study models were again taken and compared with the pre-treatment ones.

**Outcomes**

1. Reduction in anterior open bite, in mm, calculated by comparing measurements from the pre and post intervention study models
2. Reduction in overjet, in mm, calculated by comparing measurements from the pre and post intervention study models
3. Change in arch length, in mm, calculated by comparing measurements from the pre and post intervention study models.

## **Appendix 4**

### **Questions used in Semi-Structured Interviews**

Questions:

1. What is your understanding of the term interceptive orthodontics?
2. In what circumstances does it work (if any?)
3. Do you provide interceptive treatment?
4. Why (not)?
5. Are you aware of any obstacles that prevent you from providing interceptive orthodontics?
6. What type of treatment do you provide?
7. How do you feel about our ability of diagnosing cases that would benefit from interceptive treatment?
8. How confident do you feel that you are choosing the correct technique/appliance for the diagnosed problem?
9. Do you feel that interceptive orthodontics has a role in general dental practice?
10. Could anything be done to improve your provision of interceptive orthodontics?

## **Appendix 5**

### **Ethics response to Questionnaire study**

Dear Linda, Felicity & Jan

Many thanks for your response and for your forbearance. I can now confirm our advice as follows:

**Re: What are the knowledge, skill & attitudinal barriers to practising interceptive orthodontic behaviours in primary dental care? Version 2 - Felicity Borrie**

You have sought advice from the Research Ethics Office on the above project. The Scientific Officer, Assistant Admin Manager and I have considered this and can advise that this does not require ethical review under the terms of the current Governance Arrangement for Research Ethics Committees (GAfREC) in the UK. The advice is based on the following documentation provided to us:

Document	Version	Date
Emails	N/a	05 & 22 February 2010; 12 & 24 March 2010
Protocol	2	None specified
Questionnaire	None specified	January 2010

The reasons for our advice are as follows:

- There were various points that required to be addressed and this has been done.
- This is anonymous opinion survey of 300 general dental practitioners in Scotland whose patients lists include more than 10% children.

***Please note that this advice is issued on behalf of the Research Ethics Service Office and does not constitute an opinion of a Research Ethics Committee (REC). It is intended to satisfy journal editors and conference organisers, who may require evidence of consideration of the need for ethical review prior to publication or presentation of your results. If you deviate in any way from the documentation submitted, this advice may become void.***

You should keep a copy of this letter within your project file. If you require a formal letter, please let me know.

Yours sincerely

*Fiona*

Miss Fiona Bain

Admin Manager

East of Scotland Research Ethics Service

## **Appendix 6**

### **GDP Postal Questionnaire**





# **Interceptive Orthodontics in General Dental Practice**

**June 2010**



Thank you for your help with this study investigating interceptive orthodontics in General Dental Practice in Scotland. Interceptive orthodontics includes a range of interventions in the mixed dentition that aim to prevent or reduce the degree of malocclusion in the permanent dentition.

The purpose of the questionnaire is to gather information about your views around the provision of interceptive orthodontics in general practice. This is **not a test of your knowledge or an evaluation** of your current treatment methods. Different dentists will have their own interests and experiences which will be reflected in their responses.

The questionnaire should take approximately **15-20 minutes** to complete. Most of the questions require you to tick a box or circle a number. There is also space for you to comment on your answers which we hope you will use. Please be assured that your responses will be held in the strictest confidence and be anonymised. It will not be possible to identify you in any report or other publication arising from this work.

### SECTION 1:

1. Are you? Male ☐ Female ☐
  2. Please tell us your age \_\_\_\_\_ years
  3. At which university did you undertake your undergraduate training? \_\_\_\_\_
  4. Year of graduation \_\_\_\_\_
  5. Did you complete vocational training? Yes ☐ No ☐
  6. Do you hold any postgraduate qualifications? Yes ☐ No ☐
- If you answered 'yes' to Question 6, please state qualification(s):
- 
7. What is the approximate number of patients registered with you? \_\_\_\_\_
  8. Approximately what % of your patients are children  $\leq$  16 years? \_\_\_\_\_ %
  9. Is there a specialist orthodontist in the practice? Yes ☐ No ☐
  10. Is there a dentist with an interest in orthodontics (DwSI) in the practice? Yes ☐ No ☐
  11. Do you work in (please tick all that apply)?  
 GDS ☐ Salaried/CDS ☐ HDS ☐ Other ☐

## Scenario 1



This 9-year old presents to your practice for a routine check up. Both upper deciduous central incisors are present and firm with the permanent upper lateral incisors having erupted. Mum is concerned about the child's dental appearance.

Please answer the following three questions by placing ticks against the procedures given below	Which procedures would you carry out in your practice for this patient?	Which procedures do you think should ideally be carried out for this patient?	Which procedures do you feel are outwith the scope of general dental practice?
1. Refer to a specialist for treatment			
2. Refer to a specialist for a treatment plan for you to carry out the treatment			
3. Fit a space maintainer			
4. Take an alginate impression			
5. Take a periapical radiograph			
6. Take an OPT radiograph			
7. Take an Upper Anterior Occlusal radiograph			
8. Explain to parent and patient the benefits and risks of providing treatment			
9. Check for mobility of a deciduous tooth			
10. Diagnose a digit sucking habit			
11. Design & fit an upper removable appliance			
12. Restore a deciduous tooth			
13. Restore a permanent tooth			
14. Extract a deciduous tooth			
15. Extract a permanent tooth			
16. Palpate for an unerupted permanent tooth			
17. Design & fit a digit sucking deterrent appliance			
18. Design & fit a sports mouthguard			
19. Design & fit a functional appliance			
20. Provide instructions for care of the chosen appliance			
21. Nothing, reassure patient this is normal			
22. Continue to monitor the developing permanent dentition			

**Scenario 1**

Please answer the following questions by circling a number on the 1-10 scale, where 1 is not at all confident/effective/important/likely and 10 is extremely confident/effective/important/likely

1. How confident are you that you have designed an effective treatment plan for this patient?

*Not at all  
confident*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
confident*

2. How confident are you that you can effectively carry out your treatment plan for this patient?

*Not at all  
confident*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
confident*

3. How effective do you think your treatment plan can be in preventing the need for further orthodontic treatment for this patient?

*Not at all  
effective*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
effective*

4. How important do you think it is to carry out any interceptive orthodontics for this patient in primary care?

*Not at all  
important*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
important*

5. How likely is it that this patient would be worse off if you did not carry out any interceptive treatment?

*Not at all  
likely*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
likely*

6. How confident are you that the procedures you have ideally chosen for this scenario are correct?

*Not at all  
confident*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
confident*

7. How many patients, in the last 6 months, have presented with this malocclusion? \_\_\_\_\_

If you wish to comment on this scenario please do so here:

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These questions were repeated after each scenario, in the format presented above, but are not included in this appendix to avoid repetition.

**Scenario 2**

This 9-year old presents to your practice for a routine check up. The upper right central incisor is in cross bite, but the patient is unaware of this.



Please answer the following three questions by placing ticks against the procedures given below	Which procedures would you carry out in your practice for this patient?	Which procedures do you think should ideally be carried out for this patient?	Which procedures do you feel are outwith the scope of general dental practice?
1. Refer to a specialist for treatment			
2. Refer to a specialist for a treatment plan for you to carry out the treatment			
3. Fit a space maintainer			
4. Take an alginate impression			
5. Take a periapical radiograph			
6. Take an OPT radiograph			
7. Take an Upper Anterior Occlusal radiograph			
8. Explain to parent and patient the benefits and risks of providing treatment			
9. Check for mobility of a deciduous tooth			
10. Diagnose a digit sucking habit			
11. Design & fit an upper removable appliance			
12. Restore a deciduous tooth			
13. Restore a permanent tooth			
14. Extract a deciduous tooth			
15. Extract a permanent tooth			
16. Palpate for an unerupted permanent tooth			
17. Design & fit a digit sucking deterrent appliance			
18. Design & fit a sports mouthguard			
19. Design & fit a functional appliance			
20. Provide instructions for care of the chosen appliance			
21. Nothing, reassure patient this is normal			
22. Continue to monitor the developing permanent dentition			



**Scenario 3**

This patient presents to you as a new patient in the practice. They are 10-years old and are complaining of sensitivity to cold from both lower right and lower left first permanent molars (LR6 and LL6).



Please answer the following three questions by placing ticks against the procedures given below	Which procedures would you carry out in your practice for this patient?	Which procedures do you think should ideally be carried out for this patient?	Which procedures do you feel are outwith the scope of general dental practice?
1. Refer to a specialist for treatment			
2. Refer to a specialist for a treatment plan for you to carry out the treatment			
3. Fit a space maintainer			
4. Take an alginate impression			
5. Take a periapical radiograph			
6. Take an OPT radiograph			
7. Take an Upper Anterior Occlusal radiograph			
8. Explain to parent and patient the benefits and risks of providing treatment			
9. Check for mobility of a deciduous tooth			
10. Diagnose a digit sucking habit			
11. Design & fit an upper removable appliance			
12. Restore a deciduous tooth			
13. Restore a permanent tooth			
14. Extract a deciduous tooth			
15. Extract a permanent tooth			
16. Palpate for an unerupted permanent tooth			
17. Design & fit a digit sucking deterrent appliance			
18. Design & fit a sports mouthguard			
19. Design & fit a functional appliance			
20. Provide instructions for care of the chosen appliance			
21. Nothing, reassure patient this is normal			
22. Continue to monitor the developing permanent dentition			

**Scenario 4**

This 10-year old boy presents for a check up and you note that he has an increased overjet of approximately 6mm. Mum informs you that he plays a lot of sport.



Please answer the following three questions by placing ticks against the procedures given below	Which procedures would you carry out in your practice for this patient?	Which procedures do you think should ideally be carried out for this patient?	Which procedures do you feel are outwith the scope of general dental practice?
1. Refer to a specialist for treatment			
2. Refer to a specialist for a treatment plan for you to carry out the treatment			
3. Fit a space maintainer			
4. Take an alginate impression			
5. Take a periapical radiograph			
6. Take an OPT radiograph			
7. Take an Upper Anterior Occlusal radiograph			
8. Explain to parent and patient the benefits and risks of providing treatment			
9. Check for mobility of a deciduous tooth			
10. Diagnose a digit sucking habit			
11. Design & fit an upper removable appliance			
12. Restore a deciduous tooth			
13. Restore a permanent tooth			
14. Extract a deciduous tooth			
15. Extract a permanent tooth			
16. Palpate for an unerupted permanent tooth			
17. Design & fit a digit sucking deterrent appliance			
18. Design & fit a sports mouthguard			
19. Design & fit a functional appliance			
20. Provide instructions for care of the chosen appliance			
21. Nothing, reassure patient this is normal			
22. Continue to monitor the developing permanent dentition			

## Scenario 5



At a routine check up you notice that this 10-year old has developed an anterior open bite in the mixed dentition of approximately 5mm but has competent lips at rest. History reveals a digit sucking habit.

Please answer the following three questions by placing ticks against the procedures given below	Which procedures would you carry out in your practice for this patient?	Which procedures do you think should ideally be carried out for this patient?	Which procedures do you feel are outwith the scope of general dental practice?
1. Refer to a specialist for treatment			
2. Refer to a specialist for a treatment plan for you to carry out the treatment			
3. Fit a space maintainer			
4. Take an alginate impression			
5. Take a periapical radiograph			
6. Take an OPT radiograph			
7. Take an Upper Anterior Occlusal radiograph			
8. Explain to parent and patient the benefits and risks of providing treatment			
9. Check for mobility of a deciduous tooth			
10. Diagnose a digit sucking habit			
11. Design & fit an upper removable appliance			
12. Restore a deciduous tooth			
13. Restore a permanent tooth			
14. Extract a deciduous tooth			
15. Extract a permanent tooth			
16. Palpate for an unerupted permanent tooth			
17. Design & fit a digit sucking deterrent appliance			
18. Design & fit a sports mouthguard			
19. Design & fit a functional appliance			
20. Provide instructions for care of the chosen appliance			
21. Nothing, reassure patient this is normal			
22. Continue to monitor the developing permanent dentition			



### Scenario 6

At a routine check you notice that this 13-year old still has a retained lower right second deciduous molar (LRE), despite the lower left second premolar (LL5) having erupted nine months ago. The patient is wondering why she still has this baby tooth.



Please answer the following three questions by placing ticks against the procedures given below	Which procedures would you carry out in your practice for this patient?	Which procedures do you think should ideally be carried out for this patient?	Which procedures do you feel are outwith the scope of general dental practice?
1. Refer to a specialist for treatment			
2. Refer to a specialist for a treatment plan for you to carry out the treatment			
3. Fit a space maintainer			
4. Take an alginate impression			
5. Take a periapical radiograph			
6. Take an OPT radiograph			
7. Take an Upper Anterior Occlusal radiograph			
8. Explain to parent and patient the benefits and risks of providing treatment			
9. Check for mobility of a deciduous tooth			
10. Diagnose a digit sucking habit			
11. Design & fit an upper removable appliance			
12. Restore a deciduous tooth			
13. Restore a permanent tooth			
14. Extract a deciduous tooth			
15. Extract a permanent tooth			
16. Palpate for an unerupted permanent tooth			
17. Design & fit a digit sucking deterrent appliance			
18. Design & fit a sports mouthguard			
19. Design & fit a functional appliance			
20. Provide instructions for care of the chosen appliance			
21. Nothing, reassure patient this is normal			
22. Continue to monitor the developing permanent dentition			

**Scenario 7**

This 5-year old is a new patient to the practice. Mum is concerned that his teeth don't meet together. There is no history of thumb or dummy sucking.

Please answer the following three questions by placing ticks against the procedures given below	Which procedures would you carry out in your practice for this patient?	Which procedures do you think should ideally be carried out for this patient?	Which procedures do you feel are outwith the scope of general dental practice?
1. Refer to a specialist for treatment			
2. Refer to a specialist for a treatment plan for you to carry out the treatment			
3. Fit a space maintainer			
4. Take an alginate impression			
5. Take a periapical radiograph			
6. Take an OPT radiograph			
7. Take an Upper Anterior Occlusal radiograph			
8. Explain to parent and patient the benefits and risks of providing treatment			
9. Check for mobility of a deciduous tooth			
10. Diagnose a digit sucking habit			
11. Design & fit an upper removable appliance			
12. Restore a deciduous tooth			
13. Restore a permanent tooth			
14. Extract a deciduous tooth			
15. Extract a permanent tooth			
16. Palpate for an unerupted permanent tooth			
17. Design & fit a digit sucking deterrent appliance			
18. Design & fit a sports mouthguard			
19. Design & fit a functional appliance			
20. Provide instructions for care of the chosen appliance			
21. Nothing, reassure patient this is normal			
22. Continue to monitor the developing permanent dentition			

**SECTION 3:**

Please answer the following questions by circling a number on the 1-10 scale, where 1 is not at all (confident/effective/important/likely) and 10 is extremely (confident/effective/important/likely)

1. How confident are you that you can formulate effective interceptive orthodontic treatment plans for your primary care patients?

*Not at all  
confident*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
confident*

2. How confident are you that you can effectively carry out all the interceptive orthodontic procedures that are within the scope of primary care?

*Not at all  
confident*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
confident*

3. How confident are you that you can effectively carry out any interceptive orthodontics with unco-operative children?

*Not at all  
confident*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
confident*

4. How effective do you think you can be, with the provision of interceptive orthodontics, in preventing the need for further orthodontic treatment?

*Not at all  
effective*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
effective*

5. How important do you think it is to carry out any interceptive orthodontics in primary care?

*Not at all  
important*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
important*

6. In general, how likely is it that patients would be worse off if you did not carry out any interceptive treatment?

*Not at all  
likely*

1	2	3	4	5	6	7	8	9	10
---	---	---	---	---	---	---	---	---	----

*Extremely  
likely*

7. Do you feel that you are remunerated sufficiently to carry out interceptive orthodontics in general practice?

Yes

☐

No

☐

Thank you for participating in this survey. Your contribution is **very much appreciated**.

If you would like to comment on any aspect of the questionnaire, please do so here:

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Please return the questionnaire in the FREEPOST envelope provided by **[INSERT DATE HERE]**.

FREEPOST address: Interceptiv Orthodontics in GDP, Dental Health Services Research Unit, FREEPOST  
NAT15679, Dundee DD1 9XU

If you would like to discuss any part of this questionnaire or any other aspect of this survey with a member of  
the project team, please contact: Dr Felicity Borrie, Tel: 01382 635964, e-mail: [f.borrie@dundee.ac.uk](mailto:f.borrie@dundee.ac.uk)

**THANK YOU**

## **Appendix 7**

### **Detailed calculations for cost analysis**



Scenario 1 - Change in current practice from providing URA to providing FHB											
9-10 year olds in Tayside				8161		Proportion of 9 yr old with digit sucking habit					
						Presence of AOBs in previous thumb suckers					
Proportion with thumb sucking habit & AOB				353		Regular attenders at the dentist					
Proportion who attend the dentist regularly and will receive treatment				219							
Treatment											
Paint & Advice		219				Proportion applying paint and given advice			100%		
						Success rate of Paint & Advice			20%		
Persistent Habit		175				Proportion Monitored			72%		
						No co-existing malocclusion after monitoring			39%		
Monitored		126	success	49		Proportion URA			0%		
						Success URA			50%		
URA		0	success	0		Proportion FHB			28%		
						Success FHB			100%		
FHB		49	success	49		Proportion Ortho only treatment			95%		
						Proportion combined treatment			5%		
Still habit		77									
Orthodontic Treatment		73									
Combined ortho & surgery		4									
Rx Costs		Primary Care	Discounted	Hospital	Discounted	Rx Costs		Primary Care	Discounted	Hospital	Discounted
Scenario 1a	£0	£0				Scenario 1a	£0	£0			
Scenario 1b	£66,445	£51,845	£66,675	£52,019		Scenario 1b	£910.69	£710.58	£913.84		£712.97
Scenario 1c	£24,946	£18,536				Scenario 1c	£6,496.28	£4,826.99			
Scenario 2a	£0	£0				Scenario 2a	£172.21	£166.39			
Scenario 2b	£0	£0	£0	£0		Scenario 2b	£1,082.90	£876.96	£1,086.05		£879.36
Scenario 2c	£0	£0				Scenario 2c	£6,668.49	£4,993.38			
Scenario 3	£8,189	£7,912	£13,396	£12,943		Scenario 3	£167.25	£161.59	£273.59		£264.34
Total	£99,581	£78,293	£105,017	£83,498							

Scenario 2 - Scenario 1 plus provide more interceptive treatment as opposed to monitoring											
9-10 year olds in Tayside					8161	Proportion of 9yr olds who thumb suck			12%		
						Presence of AOBs in previous thumb suckers			36%		
Proportion with thumb sucking habit & AOB					353	Regular attenders at the dentist			62%		
Proportion who attend the dentist regularly and will receive treatment					219						
Treatment											
Paint & Advice			219			Proportion applying paint and given advice			100%		
						Success rate of Paint & Advice			20%		
Persistent Habit			175			Proportion Monitored			20%		
						No co-existing malocclusion after monitoring			39%		
Monitored			35	success	14	Proportion URA			0%		
						Success URA			50%		
URA			0	success	0	Proportion FHB			80%		
						Success FHB			100%		
FHB			140	success	140	Proportion Ortho only treatment			95%		
						Proportion combined treatment			5%		
Still habit			21								
Orthodontic Treatment			20								
Combined ortho & surgery			1								
Rx Costs		Primary Care	Discounted	Hospital	Discounted	Rx Costs		Primary Care	Discounted	Hospital	Discounted
Scenario 1a		£0	£0			Scenario 1a		£0	£0		
Scenario 1b		£18,457	£14,401	£18,521	£14,450	Scenario 1b		£910.69	£710.58	£913.84	£712.97
Scenario 1c		£6,930	£5,149			Scenario 1c		£6,496.28	£4,826.99		
Scenario 2a		£0	£0			Scenario 2a		£172.21	£166.39		
Scenario 2b		£0	£0	£0	£0	Scenario 2b		£1,082.90	£876.96	£1,086.05	£879.36
Scenario 2c		£0	£0			Scenario 2c		£6,668.49	£4,993.38		
Scenario 3		£23,397	£22,606	£38,274	£36,979	Scenario 3		£167.25	£161.59	£273.59	£264.34
Total		£48,784	£42,156	£63,724	£56,578						



